Explanatory Notes

1.50. A quantity is said to be property of the system, if the change in its value between two equilibrium states of the system is same for all paths.

1.57. Although, in general, work done is a path function but in case of adiabatic process, it is dependent only on end state, irrespective of path followed.

1.90.

$$\text{W.D.} = \int_{V=1}^{V_2=2} pdV = \int_1^2 (-3V + 15)\, 10^5\, dV$$

$$= \left[-\frac{3V^2}{2} + 15V\right]_1^2 \times 10^5 = \left[-\frac{3}{2}(2^2 - 1^2) + 15(2-1)\right] \times 10^5$$

$$= (-4.5 + 15) \times 10^5 = 10.5 \times 10^5 \text{ Nm or joules.}$$

1.112.

$$PV = \text{M.R.T.}$$

$$M = \text{Molecular weight}$$

and $$MR = 8341 \text{ J/kg mol °K}$$

$\therefore$ $$600 \times 10^3 \times V = 8341 \times (273 + 27)$$

and $$V = \frac{8341 \times 300}{600 \times 10^3} = 4.17 \text{ m}^3\text{/kg mol.}$$

1.113. According to first law of thermodynamics,

$$Q = \Delta U + W$$

or $$-300 = 0 + W$$

and $$W = -300 \text{ kJ} = -300 \times 10^3 \text{ Nm.}$$

1.166. For Carnot engine

$$\eta = \frac{T_1 - T_2}{T_1}$$

$$= \frac{(273 + 227) - (273 + 27)}{500} = \frac{200}{500} = 40\%$$

η of engine of manufacturer $$= \frac{\text{Net work}}{\text{Heat added}} = \frac{20 \times 4500}{427 \times 400} = 50.3\%$$

No engine can be more efficient than Carnot engine, irrespective of cost and sophistication. So it is impossible.

1.168.

$$\eta_{carnot} = \frac{(627 + 273) - (27 + 273)}{900} = 67\%.$$

$$\eta_{actual} = \frac{50 \times 1000 \times 60 \times 60}{3 \times 75{,}000 \times 1000} = 80\%. \qquad \text{So, impossible.}$$

1.176.

$$Q = \Delta U + W$$

$$-200 = \Delta U + \int_1^2 pdv$$

or

$$\Delta U = -200 - \frac{4.27}{427} \times 10^4 (2-4)$$

$$= -200 + 200 = 0.$$

1.179.

$$\frac{\delta Q_1}{T_1} = \frac{1130}{565} = 2 \text{ kcal/mt/}^\circ\text{K}$$

$$\frac{\delta Q_2}{T_2} = \frac{630}{315} = 2$$

∴ $\int \frac{\delta Q}{T} = 2$, and process will be reversible.

1.180.

$$\frac{\delta Q_1}{T_1} = 2$$

and

$$\frac{\delta Q_2}{T_2} = \frac{315}{315} = 1.$$

∴ $\int \frac{\delta Q}{T} = 1$, and process is impossible.

1.181.

$$\frac{\delta Q_1}{T_1} = 2.$$

and

$$\frac{\delta Q_2}{T_2} = \frac{945}{315} = 3.$$

∴ $\int \frac{\delta Q}{T} = -1$, and process is irreversible.

1.182.

$$\eta = \frac{\text{Work done}}{\text{Heat supplied}} = \frac{10 \text{ kW}}{30{,}000 \text{ J/s}}$$

$$= \frac{9 \times 10^3 \text{ watts or J/s}}{30{,}000} = 0.3 \text{ or } 30\%.$$

1.183. Heat rejected $= Q - W$

$$= 30{,}000 - 9{,}000 = 21{,}000 \text{ J/s}$$

1.187.

$$\text{COP}_{(heat\ pump)} = \frac{\text{Heat to be pumped to higher temp}}{\text{Work to be done}}$$

$$= \frac{60}{8} = 7.5.$$

1.188.

$$\text{COP}_{(refrigeration)} = \frac{\text{Heat abstracted from room}}{\text{W.D.}}$$

W.D. = Heat to be pumped to higher temp.

– Heat abstracted from hot place

∴ Heat abstracted from room $60 - 8 = 52$ Mcal/hr

and

$$\text{COP} = \frac{52}{8} = 6.5.$$

1.292.

$$H = U + PV$$

$= 3.5 \times 10^6 + 0.3 \times 10^6 \times 1.5/3$

$= (3.5 + 0.15) \times 10^6 \text{ J} = 3.65 \text{ MJ}$

$\therefore$ Enthalpy for 3 kg $= 3 \times 3.65 = 10.95 \text{ MJ}$.

2.4. In super-charging, the air of increased density should be retained in the power cylinders after the exhaust ports or the valves are closed.

2.11. High heat value of oil containing hydrogen includes some heat not available for conversion into work in heat engine. However the heat value of oil being easier to find and there being a fairly constant percentage between low and high values of fuel oil, fuel oil consumption guarantees are based on high heat value.

2.16. In case of gaseous fuel, there being considerable variation between low and high value depending on presence of hydrogen content, the guarantees are for low heat value which is actually usefully utilised.

2.47. All the methods are correct, but the best, easiest, most convenient and practical way is (*d*).

2.237. For scavenging/supercharging, the increased density air should be retained in the lower crankcase after the exhaust ports or the valves are closed.

2.251. Sensitivity of governor

$$= \frac{n_1 - n_2}{\dfrac{n_1 + n_2}{2}} \times 100 = \frac{980 - 970}{\dfrac{980 + 970}{2}} \times 100 = \frac{10 \times 200}{1950} \cong 1\%.$$

4.124. In longitudinal direction, there is twice the unit stress compared to circumferential seam.

4.127. Higher is the chimney, more will be the area of spread of pollutants and less pollutant in unit volume of surrounding air. It may be noted that in big power plants, the main purpose of chimney is not to create draft but to control pollution.

4.212. It may be noted that all four are correct but (*a*) is most predominant cause.

4.224. All four answers are correct but (*a*) is best reason.

4.253. Total angle to be moved is 10° for old angle of advance plus 90° for old zero angle ahead of crank plus 90° for new zero angle ahead of crank and 10° for new angle of advance = 200°.

5.10. Aim should be to take coolest and clean and dry air.

5.40. Shade side provides cooler air around receiver thereby knocking out moisture and furnish dry air.

5.58. At high altitude density of air is low and as such compressed volume will be low.

5.59. At high altitudes, mass of air compressed is low.

5.60. During peaking, frequent start/stop of motor may be required which is not desirable, therefore, unloading of cylinder method is best. Variable speed is costly method and generally not used.

5.71. No gain will be there by idling the compressor and it is better to stop the motor, as start-stop will not be frequent.

6.42.

$$q = \frac{A(T_1 - T_2)}{\left(\dfrac{t_1}{k_1} + \dfrac{t_2}{k_2} + \dfrac{t_3}{k_3}\right)} = \frac{1.2 \times (1027 - 27)}{\left(\dfrac{0.2}{2} + \dfrac{0.15}{0.15} + \dfrac{0.15}{1.5}\right)}$$

$$= \frac{1.2 \times 1000}{0.1 + 1 + 0.1}$$

$$= 1000 \text{ kcal/hr.}$$

7.55. $$\eta_{carnot} = \frac{T_1 - T_2}{T_1} = 0.8$$

$$\text{COP} = \frac{T_2}{T_1 - T_2}$$

$$T_1 - T_2 = 0.8T_1, \text{ or } 0.2T_1 = T_2$$

or $$T_1 = 5T_2$$

∴ $$\text{COP} = \frac{T_2}{5T_2 - T_2} = \frac{1}{4} = 0.25.$$

8.104. As density of atmosphere varies with altitude, decrease is not linear.

8.113. It is an ordinary manometer containing only the fluid in conduit and thus very sensitive.

8.143. Weight in air = Weight in water + $\rho \times V$

or $$3 = 2.5 + 1000 \times V$$

or $$V = \frac{0.5}{1000}$$

∴ $$\text{S.G.} = \frac{\text{Wt. in air}}{V \times \rho} = \frac{3 \times 1000}{0.5 \times 1000} = 6.$$

8.163. Froude No. of prototype = Froude No. of model

or $$\frac{V}{\sqrt{gL}} = \frac{V'}{\sqrt{g'L'}} \qquad \frac{V}{\sqrt{L}} = \frac{V'}{\sqrt{L'}} \qquad (\text{as } g = g')$$

∴ $$\frac{10}{\sqrt{100}} = \frac{V'}{\sqrt{100/25}}$$ or $\frac{10}{10} = \frac{V'}{2}$ and $V' = 2$ m/sec.

8.165. Reynold No. of prototype and model has to be same.

∴ $$\frac{5 \times l}{\mu} = \frac{25 \times l'}{\mu'} \qquad (\mu = \mu')$$

∴ $$\frac{l}{l'} = \frac{5}{25} = 1 : 5.$$

8.215. If V is volume of metal, and x the fraction under mercury, then

$$\frac{xV}{V} = \frac{7}{13.6}$$

and $$x = 0.515.$$

8.216. If V is total volume of wood, and S its sp. gravity ; and if V is volume under water, then

$$\frac{V'}{V} = \frac{S}{1}$$

or $$S = \frac{60}{100} = 0.6.$$

8.448. Head loss in hydraulic jump $= \dfrac{(y_1 - y_2)^2}{4y_1y_2}$

10.179 and 10.180. Fig. 5-A (*a*) shows the free body diagram for all the forces and Fig. 5-A (*b*) shows the force triangle for these.

It will be noted that force triangle is similar to ΔABC shown in Fig. 7.19 in the Prob. 10.179.

∴ From similar triangles

Free Body Diag.
Fig. 5-A (*a*)

Force Triangle
Fig. 5-A (*b*)

$$\frac{F_{AB}}{5} = \frac{F_{BC}}{3} = \frac{1500}{6}$$

or $$F_{AB} = \frac{1500 \times 5}{6} = 1250 \text{ kg}$$

and $$F_{BC} = \frac{1500 \times 3}{6} = 750 \text{ kg}$$

10.181 and 10.182. Fig 5-B (*a*) shows the force diagram and 5–B (*b*) shows the free body diagram for the forces.

By Lami's theorem,

$$\frac{P}{\sin 150°} = \frac{N}{\sin 150°} = \frac{500}{\sin 60°}$$

$$P = 500 \times \frac{\sin 150°}{\sin 60°} = 5000 \times \frac{\sin 30°}{\sin 60°}$$

$$= \frac{500 \times 1/2}{\sqrt{3}/2} = \frac{500}{\sqrt{3}} = \frac{500 \times \sqrt{3}}{3}$$

$$= \frac{500 \times 1.732}{3} = \frac{866}{3} = 288 \text{ kg.}$$

Similarly $N = 288$ kg.

Force Diag
Fig. 5-B (*a*)

Free Body Diag
5-B (*b*)

10.183 and 10.184. Weight of bar *AB* can be assumed to act at the mid point. Since the bar is in equilibrium under the action of three external forces, the lines of action of these forces must be concurrent. Fig. 5-C (*a*) shows the free body diagram of the bar and Fig. 5-C (*b*) shows the corresponding force triangle, which is equilateral triangle.

$\therefore$ $$R = T = 100 \text{ kg.}$$

10.187. As the forces in the vertical direction must be balanced.

$\therefore$ $$T \cos\theta = W$$

Free Body Diag
Fig. 5-C (*a*)

Force Δ
Fig. 5-C (*b*)

Forces in the direction normal to the circular path of rotation are unbalanced such that

$$T \sin\theta = \frac{W}{g} a_n = \frac{W}{g} \cdot \omega^2 r$$

$$= \frac{W}{g} \omega^2 \cdot l \sin\theta$$

$$T = \frac{W}{g} \omega^2 l$$

10.189. Unbalanced force $= 30 - 20 = 10$ kg.

It acts on two weights so that $10 = \frac{50}{g} \times a$

and $a = g/5$

20 kg weight is accelerated upward

$\therefore$ Tension = 20 kg + unbalanced force necessary to give it an upward acceleration of $g/5$
$= 20 + 20/g \times g/5 = 24$ kg.

10.191. Work of spring

= K.E. of car

$$= \left(\frac{\text{Resistance of spring in kg/cm}}{2}\right) \times (\text{Deflection of spring})^2$$

or $$\frac{1}{2}\frac{W}{g}v^2 = \frac{R}{2} \times h^2$$

or $$\frac{50,000}{9.81} \times (100)^2 = R \times 10^2$$

or $$R = \frac{500 \times 10^4}{9.81} \cong 50 \times 10^4 \text{ kg/cm}$$

10.195. Weight × Distance of free fall+ Weight × Displament of spring (h) = Work of spring

$$= \text{Average force of spring} \times h^2$$

$$1000 \times 8 + 1000 \times h = \frac{500}{2} \times h^2$$

or $$32 + 4h = h^2$$

or $$h^2 - 4h - 32 = 0$$

or $$(h-8)(h+4) = 0$$

or $$h = 8 \text{ cm}$$

or $$= -4 \text{ cm}$$

10.196. $$\text{Velocity} = \text{Acceleration} \times \text{Time}$$

or $$4 \text{ m/sec} = a \times 2$$

and $$a = 2 \text{ m/sec}^2$$

Tension in cable $$= \frac{W}{g}(g+a)$$

$$= \frac{1000}{9.81}(9.81+2) = \frac{11,810}{9.81} \cong 1200 \text{ kg.}$$

10.198. $$(\text{Final velocity})^2 = (\text{Initial velocity})^2 + 2a \times \text{Distance}$$

or $$0 = 4^2 + 2a \times 2$$

or $$a = -4 \text{ m/sec}$$

∴ Tension in cable $$= \frac{W}{g}(g+a) = \frac{1000}{9.81}(9.81-4)$$

$$= \frac{5810}{9.81} = 590 \text{ kg.}$$

10.199. Vertical height of wall where the ladder rests is

$$\sqrt{13^3 - 5^2} = 12 \text{ m.}$$

At vertical wall, only horizontal normal force (S) acts, and at ground, normal reaction R and frictional force F act.

∴ $$F = S$$

and $$R = \text{Weight of ladder } (W)$$

Taking moments about point on ground where ladder rests,

$$W \times 2.5 = S \times 12 = F \times 12$$

or $$F = \frac{2.5}{12} W \cong 0.21W$$

$$\mu = \frac{F}{R} = \frac{F}{W} \cong 0.2.$$

10.298. When the disc rolls down an inclined plane, apart from possessing translatory motion, it rotates about an axis passing through its centre of gravity and perpendicular to its plane.

$\therefore$ K.E. of rotation of the disc about this axis

$$= \tfrac{1}{2} I\omega^2 = \tfrac{1}{2}\left(\tfrac{1}{2}Mr^2\right)\omega^2 = \tfrac{1}{4}Mr^2\omega^2 = \tfrac{1}{4}Mv^2.$$

Here I = M.I. of the disc about the said axis,
M = mass of the disc,
r = radius of the disc,
v = linear velocity of the disc,
ω = angular velocity of the disc.

K.E. of translation $= \tfrac{1}{2}Mv^2$

Total energy of the disc $= \tfrac{1}{4}Mv^2 + \tfrac{1}{2}Mv^2 = \tfrac{3}{4}Mv^2$

$\therefore$ fraction of total energy associated with rotation

$$= \frac{\tfrac{1}{2}Mv^2}{\tfrac{3}{4}Mv^2} = \tfrac{1}{3}.$$

10.299. As K.E. of rotation $= \tfrac{1}{2}I\omega^2$, it depends upon I (moment of inertia) and ω. Further, I depends upon the *distribution of mass*, apart from its dependence upon the mass and the position and direction of the axis of rotation.

10.301. The velocity of satellite in an orbit close to the surface of the earth is given by

$$V_e = \sqrt{gR}$$

10.303. It is due to the state of weightlessness during the time of free fall.

10.304. The escape velocity depends upon the planet.

10.309. The length of the second's pendulum ($T = 2$ seconds) is given by

$$L = \frac{g}{\pi^2}. \qquad \left(\because\ 2 = 2\pi\sqrt{\frac{L}{g}} \text{ or } 1 = \pi^2\frac{L}{g}\right)$$

Since the value of g on moon is $\tfrac{1}{6}$th of its value on earth, the length of the second's pendulum on the surface of moon is $\tfrac{1}{6}$th of that on earth.

10.310. A damped oscillator is one whose amplitude goes on decreasing. The energy of a harmonic oscillator is directly proportional to the square of its amplitude. Since the amplitude decreases exponentially, the energy will also decrease exponentially with time.

10.311. When the body is dropped from one end of the tunnel, it will be attracted towards the centre of the earth due to the gravitational force. Under the influence of this force, its velocity goes on increasing till it reaches the centre. At the centre its velocity is maximum. This maximum velocity will take the body away from the centre towards the other end. But as it moves away from the centre, its velocity goes on decreasing as it is being attracted towards the centre of the earth. On reaching the other end, the velocity becomes zero and the body is again attracted towards the centre with increasing velocity. Thus the body executes S.H.M. about the centre of earth.

10.314. When the lift is moving downwards, the apparent weight of the bob decreases and as also the effective value of g. Since $T = 2\pi\sqrt{l/g}$, with decrease in the effective value of g, T also increases (*i.e.* it is maximum out of all the given cases).

10.315. The time period of a loaded light spring is given by

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Obviously, as m increases, T also increases.

10.316. The swing is like a simple pendulum whose time period is given by $T = 2\pi\sqrt{\frac{l}{g}}$, which obviously is independent of the mass on the swing. Thus when another boys sits on the swing without disturbing its motion, the mass on the swing increases, but the time period remains unchanged.

11.101. These components of 600 kg force will be 360 and 480 and of 200 kg force will be 160 and – 120 kg; thus resultant of these two will be 360 + 60 and 480 – 120.

11.156. In winter inside temperature will drop and result in decrease of internal pressure. With a greater external pressure, the walls of the vessel are placed in compression with resultant buckling.

11.163. Beam will remain horizontal, if both beams stretch equally.

∴ $$\left(\frac{Fl}{EA}\right)_{steel} = \left(\frac{Fl}{EA}\right)_{Aluminium}$$

or $$\frac{F_S}{F_A} = \frac{1}{2} \times \frac{2 \times 10^6}{1 \times 10^6} \times \frac{1}{2} = \frac{1}{2}$$

11.164. For static equilibrium, $\Sigma F_Y = 0$

and $\Sigma M_S = 0$

∴ $F_S + F_A = P$

or $\frac{1}{2}F_A + F_A = P$

and $F_A = \frac{2}{3}P$

Also $F \times l = \frac{2}{3}P \times 2$

or $l = 4/3 = 1.33$ m.

11.165. $$\mu = \frac{\text{Lateral strain}}{\text{Axial strain}} = \frac{0.005/10}{0.08/40}$$

$$= \frac{0.0005}{0.002} = 0.25.$$

11.166. This will be possible when differential contraction of steel and brass columns equals the static deflection on two steel columns,

i.e. $$\alpha_b - \alpha_s = \frac{1}{2}\left(\frac{PL}{EA}\right)_S$$

or $$L \times \Delta T \times (20 \times 10^{-6} - 10 \times 10^{-6})$$
$$= \frac{1}{2} \times \frac{10 \times 10^3 \times L}{2 \times 10^6 \times 10}$$

or $$\Delta T = \frac{1}{4} \times \frac{10^3}{10 \times 2} = 12.5°\text{C decreases.}$$

11.168. In this case $\left(\frac{PL}{EA}\right)_S + \left(\frac{PL}{EA}\right)_B$
$$= (\alpha L \Delta T)_S + (\alpha L \Delta T)_B$$

or

$$P\left(\frac{100}{2\times10^6\times10}+\frac{100}{1\times10^6\times20}\right)$$

$$= 25\times100\,[(20-10)\times10^{-6}]$$

or

$$P=\frac{25\times100\times10}{10}=2500\text{ kg.}$$

11.284. This is the case of parallel shafts and angle of twists are equal in both.

11.340. Ten bricks are held together by a force of 50 kg, so compressive stress binding them together is $\frac{50}{25\times25}$ kg/cm^2.

The moment bottom fibres of bricks are in tension, the blocks will come out.

So tensile loading due to B.M. had to be limited to

$$=\frac{50}{25\times25}\text{ kg/cm}^2.$$

If P is load at centre, then B.M.

$$=\frac{P\times l}{4}=\frac{P\times25\times10}{4}$$

and tensile stress due to it

$$=\frac{4}{\dfrac{35\times25^2}{6}}$$

or

$$\frac{50}{25\times25}=\frac{P\times25\times10\times6}{4\times25\times25^2}$$

or

$$P=\frac{10}{3}=3.34\text{ kg.}$$

11.341. The resultant of forces acting is $\sqrt{2}P$ across diagonal to square beam.

$$\text{B.M.}=\sqrt{P}\times l$$

Bending stress

$$=\frac{\sqrt{2}Pl}{I}\times y$$

$$=\frac{\sqrt{2}Pl}{\dfrac{d^4}{12}}\times\frac{d}{\sqrt{2}}=\frac{12Pl}{d^3}$$

$$\left(I\text{ across diagonal}=\frac{d^2}{12}\right)$$

11.342.

$$\left(\frac{l}{r}\right)^2_{min}=\frac{\pi^2E}{s_{y.p.}}=\frac{\pi^2\times2\times10^3}{6000}$$

and

$$\left(\frac{l}{r}\right)^2_{min}=\pi\times\sqrt{\frac{1000}{5}}\cong57.$$

12.82. There is nothing like efficiency of structures.

12.97. Kinematic chain is one which satisfies

$$L=\frac{2}{3}(J+2),$$

which is not satisfied in this case.

12.101. Eccentric sheave is equivalent to 2 links, 1 link is due to oscillatory link, and one is fixed link.

12.112.
$$\left(J+\frac{1}{2}H\right)=3/2L-2,$$
or
$$7+0=3/2\times 6-2$$
or
$$7=7.$$

∴ Kinematically sound.

12.121.
$$f=\frac{1}{2\pi}\sqrt{\frac{2g}{3(R-r)}}$$
R = radius of cylindrical surface
r = radius of cylinder

12.172.
$$\omega=\frac{2\pi\times 800}{60}=83.85 \text{ rad/sec.}$$
$$\omega_p=\frac{V}{R}=\frac{240\times 1000}{170\times 60\times 60}=0.392 \text{ rad/sec}^2.$$
∴
$$C=I\omega\omega_p$$
$$=\frac{30}{9.81}\times 83.85\times 0.392=100 \text{ mkgf.}$$

PART III

SOLVED OBJECTIVE TYPE QUESTIONS AND ANSWERS IN MECHANICAL ENGINEERING

Solved Objective Type Questions and Answers in Mechanical Engineering

1. The four laws of thermodynamics deal with
(*A*) conservation of energy (*B*) thermal equilibrium
(*C*) law regarding conversion of heat to work
(*D*) non attainment of absolute zero temperature.
The zeroth, first, second, and third laws of thermodynamics are concerned with
(*a*) *A, B, C, D* (*b*) *B, A, C, D*
(*c*) *A, C, D, B* (*d*) *B, C, A, D*
(*e*) *C, D, B, A.*

Sol. (*b*) Zeroth law deals with thermal equilibrium and according to it; if in an isolated system, each of two bodies is in thermal equilibrium with third body, then the two bodies are also in thermal equilibrium.

First law of thermodynamics is the law of conservation, requiring that the mass and energy of any given system be indestructible, although capable of a change of form.

Second law deals with rules for conversion of heat to work.

According to Kelvin-Planck statement; It is impossible to construct an engine that, operating in a cycle, will produce no effect other than the extraction of heat from a reservoir and the performance of an equivalent amount of work.

According to Clausius statement; It is impossible to construct a device that, operating in a cycle, will produce no effect other than the transfer of heat from a cooler to a hotter body.

According to third law of thermodynamics, as per Zemansters it is impossible by any procedure, no matter how idealised, to reduce any system to the absolute zero of temperature in a finite number of operations. As per Keenan, at zero temperature, a system may assume several states having less entropy than all other states.

2. Which of the following represents irreversible process
(*a*) isentropic (*b*) adiabatic
(*c*) counterflow heat transfer between like fluids separated by an infinitesimal temperature difference
(*d*) real engine (*e*) Carnot engine.

Sol. (*d*) Processes at (*a*), (*b*), and (*c*) are reversible type since these processes can be extactly retracted point by point in such a way that the energy added is exactly equivalent to the energy originally given up. Carnot engine also consists of only reversible paths and is in fact a theoretically perfect cycle.

However real engine encounters the sources of irreversibility, *viz* friction and direct heat transfer across a finite temperature difference.

3. Fig. 1 given below represents various commonly used cycles in thermodynamics on temperature (T) versus entropy (S) diagrams.

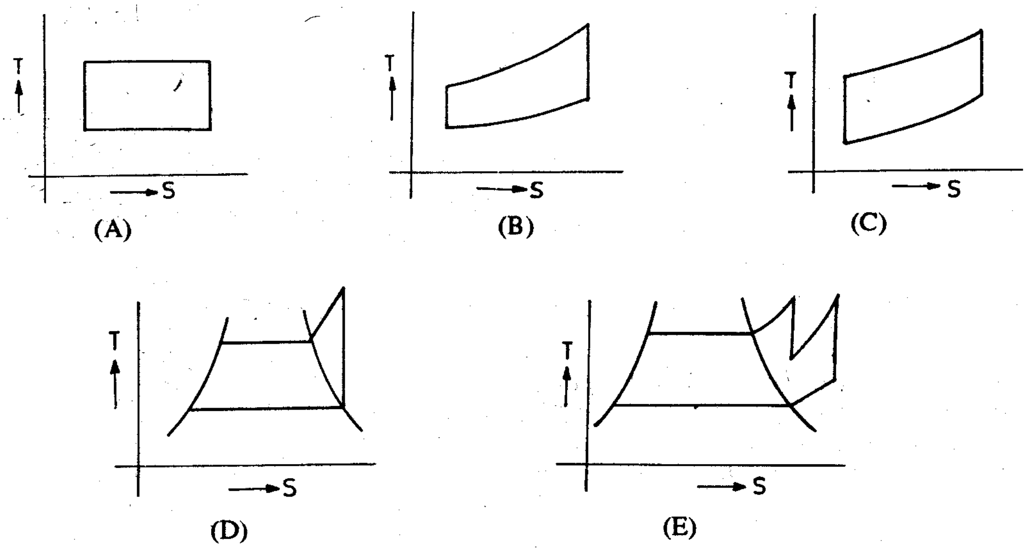


Fig. 1

The Brayton cycle, Carnot cycle, Reheat cycle, Otto cycle, and Rankine cycle are represented respectively by

(*a*) *C, A, E, B, D* (*b*) *B, A, E, C, D*
(*c*) *A, C, E, B, D* (*d*) *C, A, D, B, E*
(*e*) *D, A, E, B, C.*

Sol. (*a*) Carnot cycle consists of 2 isothermals and 2 isentropics and is thus shown at *A*.

Otto cycle comprises of isentropic compression, heating at constant volume, isentropic expansion, heat rejection at constant volume. It is represented by *B*.

Brayton cycle consists of 2 isentropics and 2 constant pressure lines. Refer Fig. *C*.

Figs. *D* and *E* represent Rankine cycle and reheating cycles.

4. Fig. 2 shows the relation between the properties of saturated steam. The curves of pressure-volume, pressure-temperature and pressure-density are represented respectively by curves.

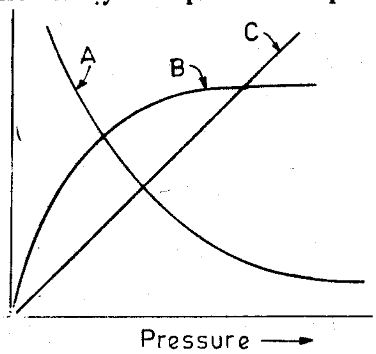


Fig. 2

(*a*) *A, B, C* (*b*) *B, A, C*
(*c*) *C, A, B* (*d*) *C, B, A*
(*e*) *B, C, A.*

Sol. (*a*) It may be noted that pressure-volume is related by formula $pv^n = C$ and thus represented by curve *A*. Pressure-density is roughly linear relationship and thus shown by curve *C*.
As regards temperature, it increases much more rapidly with increase of pressure at lower than at higher pressures and thus represented by curve *B*.

5. One edge of a square plate is maintained at 100°C while the other three are kept at 0°C. The temperature (*T*) at the centre of the plate will be

(*a*) 100°C (*b*) 0°C
(*c*) 50°C (*d*) 25°C
(*e*) 75°C.

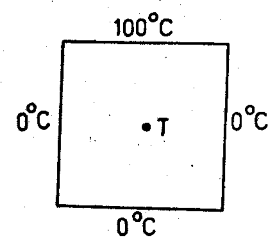


Fig. 3

Sol. (*d*) If square plate is supposed to have a constant temperature of 100°C throughout and be assumed to be consisting of four plates stacked one on top of the other (Ref. Fig. 4) then the centre temperatures are the same in all four cases and say equal to *T*. With the principle of superposition.

$$4T = 100°C \quad \text{and} \quad T = 25°C$$

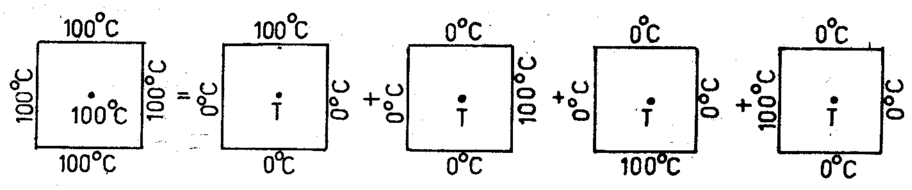


Fig. 4

6. If N = no. of stages in which compression of air is accomplished, P_a = atmospheric pressure, P_f = final air pressure, n = exponent of compression curve, V = volume of air at atmospheric pressure, then horse power required to compress air is proportional to

(*a*) $\dfrac{NPVn}{n-1}\left[\left(\dfrac{P_f}{P_a}\right)^{(n-1)/Nn} - 1\right]$ (*b*) $PV\left[\left(\dfrac{P_f}{P_a}\right)^{n-1} - 1\right]$

(*c*) $\dfrac{PV}{n-1}\left[\left(\dfrac{P_f}{P_a}\right)^{(n-1)/N} - 1\right]$ (*d*) $\dfrac{NPV}{n-1}\left[\left(\dfrac{P_f}{P_a}\right)^{nN/(n-1)} - 1\right]$

(*e*) $\dfrac{NPV(n-1)}{n}\left[\left(\dfrac{P_f}{P_a}\right)^{(n-1)/nN} - 1\right]$

Sol. (*a*) The correct relationship is as per (*a*) because it may be remembered that h.p. is proportional to $\dfrac{Nn}{n-1}$, and power of $\left(\dfrac{P_f}{P_a}\right)$ is $\dfrac{n-1}{Nn}$.

7. The horse-power required to compress initial volume (V) of atmospheric air at pressure P to pressure P' isothermally is proportional to

(*a*) $PV\left(\log_e \dfrac{P'}{P}\right)$ (*b*) $PV\left(\log_e \dfrac{P'}{P} - 1\right)$

(*c*) $PV\left(\log_e \dfrac{P'}{P} + 1\right)$ (*d*) $PV\left[\log_e\left(\dfrac{P'}{P} + 1\right)\right]$

(*e*) $PV\left[\log_e\left(\dfrac{P'}{P} - 1\right)\right]$.

Sol. (*a*) The correct relationship is as at (*a*) because it may be remembered that in case of isothermal compression, h.p. is proportional to $\left(\log_e \frac{P'}{P}\right)$.

8. Compressor characteristics are usually plotted in terms of the dimensionless parameters (*viz.* mass flow parameter $m\sqrt{T_1}/P_1$ pressure parameter p_2/p_1, and speed parameter $N/\sqrt{T_1}$) in order to correlate performance at various values of intake pressure and temperature. A typical compressor "map" is shown in Fig. 5. *A*, *B* and *C* in Fig. 5 respectively refer to

(*a*) $N/\sqrt{T_1}, m\sqrt{T_1}/p_1, p_2/p_1$
(*b*) $m\sqrt{T_1}/p_1, N/\sqrt{T_1}, p_2/p_1$
(*c*) $m\sqrt{T_1}/p_1, p_2/p_1, N/\sqrt{T_1}$
(*d*) $p_2/p_1, m\sqrt{T_1}/p_1, N/\sqrt{T_1}$
(*e*) $N/\sqrt{T_1}, p_2/p_1, m\sqrt{T}/p_1$.

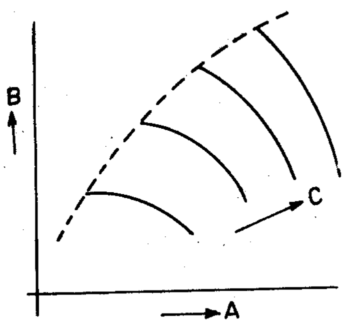


Fig. 5

Sol. (*c*) The *x*-axis in Fig. 5 represents mass flow parameter, and *y*-axis the pressure parameter. These curves are drawn for various speed (*C*) parameters.

9. Fig. 6 shows how the exhaust temperature, brake mean effective pressure, and specific fuel consumption vary in a typical stationary diesel engine. These parameters are represented by the curves

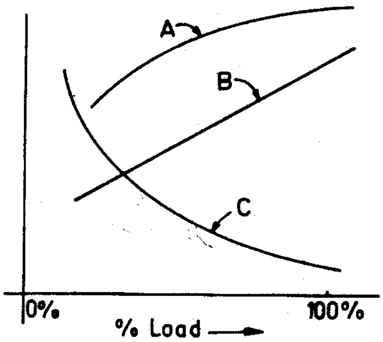


Fig. 6

(*a*) *A*, *B*, *C* (*b*) *A*, *C*, *B*
(*c*) *B*, *A*, *C* (*d*) *B*, *C*, *A*
(*e*) *C*, *A*, *B*.

Sol. (*c*) The exhaust temperature increases linearly with increase in load and is represented by curve *B*.

The specific fuel consumption is maximum at lower loads because of constant friction (being proportionately higher at lower loads) and increases continuously upto full load. It is represented by curve *C*. B.M.E.P. increases initially at a faster rate but tries to flatten near full load. It is represented by curve *A*.

10. Which of the following analysis is used to determine the behaviour of the coal and its suitability for a particular boiler

(*a*) critical analysis (*b*) flue gas analysis
(*c*) gravimetric analysis (*d*) proximate analysis
(*e*) ultimate analysis.

Sol. (*d*) Proximate analysis determines the four parts, *viz.* moisture, volatile matter, ash, and fixed carbon. This is used to determine behaviour of coil and its suitability for a particular boiler.

11. Which of the following analysis accurately determines the chemical elements present in coal
(*a*) flue gas analysis (*b*) ultimate analysis
(*c*) proximate analysis (*d*) volumetric analysis
(*e*) approximate analysis.

Sol. (*b*) Ultimate analysis accurately determines the chemical elements (ash, moisture, carbon, hydrogen, nitrogen, sulphur, oxygen) present in the coal. This can indicate the amount of air required for combustion and consequently the products of combustion to be found in the flue gas.

12. Fig. 7 shows the steam temperature rise in following superheater types
(*i*) radiant (*ii*) convection
(*iii*) combined radiant and convection.

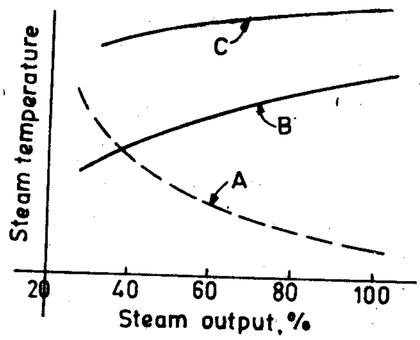


Fig. 7

The curves applicable for these three cases are
(*a*) *A, B, C* (*b*) *B, A, C*
(*c*) *A, C, B* (*d*) *B, C, A*
(*e*) *C, A, B.*

Sol. (*a*) Radiant superheaters are directly exposed to furnace gases. After 40% load, the temperature of furnace remains nearly same and as such heat transfer by radiation is same but high steam flow rate takes away more heat and thus drooping curves *A* is applicable.

In case of convection superheater, temperature of steam rises at higher load due to flow of more flue gases around its surface (curve *B*).

The effect of these two superheaters combined is to flatten the curve and obtain nearly uniform temperature at all the loads (curve *C*).

13. Which superheater in a boiler has a drooping characteristics
(*a*) pendent superheater (*b*) convection superheater
(*c*) radiant superheater (*d*) conduction superheater
(*e*) combination superheater.

Sol. (*c*) Radiant superheater has drooping characteristics because as load is increased, more steam flows through it, and this being located in hottest zone to begin with, there is little additional radiation effect and steam temperature thus decreases with increase in load.

14. The superheat temperature on combined type superheaters with increase in excess air
(*a*) increases (*b*) decreases
(*c*) remains unaffected
(*d*) may increase/decrease depending on other variables
(*e*) none of the above.

Sol. (*a*) When there is excess air, less steam is generated. Thus the superheater has comparatively more heat available for each unit mass of steam generated and the superheat temperature rises.

15. What happens to economisers in boiler, if the feed water temperature is too low due to all heaters being out
(*a*) tube life increases due to handling of low temperature water
(*b*) efficiency of heat transfer increases
(*c*) economiser works more efficiently due to picking up high heat from flue gases
(*d*) corrosion results
(*e*) scale formation increases.

Sol. (*d*) Low feed water temperature results in condensation on the gas side of economiser tubes; which leads to corrosion due to acid attack (due to sulphur present in gases) on the gas side of the tubes.

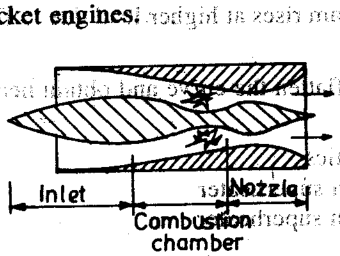
16. Wankel engine is
(*a*) a conventional internal-combustion engine
(*b*) a jet engine used for aeroplanes (*c*) a gas turbine
(*d*) a rotary engine (*e*) useful for space rocket.

Sol. (*d*) Wankel engine was invented in 1954 and introduced as a gasoline engine for automobiles in 1968. A three-sided inner rotor moves within an outer rotor or casting, forming chambers within which the four-stroke cycle can be performed without conventional valves. It has advantages of less weight, economy, compactness, and smooth running.

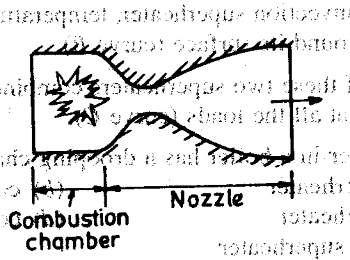
17. Nitromethane, diborane, hydrazine nitrate, concentrated hydrogen peroxide, etc., are used as
(*a*) rocket fuels (*b*) lubricants
(*c*) cutting fluids (*d*) oxidising agents in furnaces
(*e*) detergents.

Sol. (*a*) The items listed are used as rocket fuels since these possess properties like high specific impulse per unit volume, high heat of combustion, high density, low molecular-weight combustion products, etc.

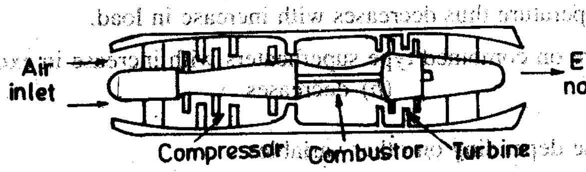
18. In aeronautics one often comes across following types of engines
(1) Turbojet (1) Turbopropeller
(3) Turbofan (4) Ramjet engine
(5) Rocket engines.



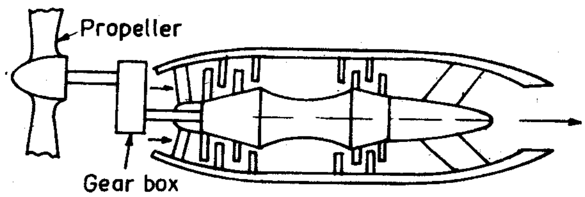
(A)



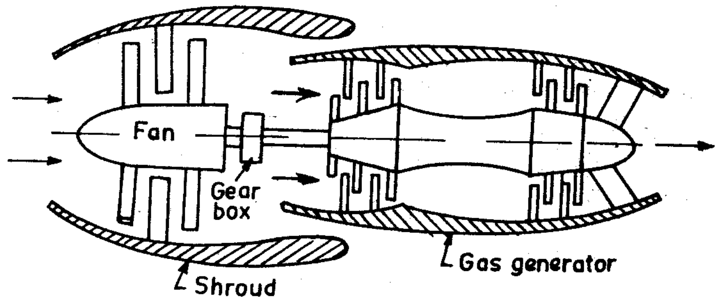
(B)



(C)



(D)



(E)
Fig. 8

These are shown respectively by figures

(*a*) A, B, C, D, E
(*b*) C, D, E, A, B
(*c*) D, C, E, B, A
(*d*) E, D, C, A, B
(*e*) D, C, A, E, B.

Sol. (*b*) Fig. 8 (*a*) shows ramjet engine, (*b*) shows rocket engine, (*c*) shows turbojet, (*d*) shows turbo propeller, and (*e*) shows turbofan.

19. Items at 1, 2, 3 and 4 below are commonly used in connection with cogeneration, an important energy-producing technology, which is catching everybody's attention today. Which items in second column best describe these terms

(1) Cogeneration	(A) A system which combines a gas turbine, waste heat boiler and a steam turbine to maximise the efficiency of steam and electrical production
(2) Combined cylce	(B) Aircraft engines that have been adapted and modified for industrial use as prime movers
(3) Waste-to-energy	(C) Simultaneous generation of electrical and thermal power using one energy source
(4) Aeroderivatives	(D) The conversion of biomass or other waste products into useful energy by combustion which ultimately produces steam and electricity

The sequence for 1, 2, 3, and 4 is

(*a*) C, A, D, B
(*b*) A, C, B, D
(*c*) C, A, B, D
(*d*) B, C, A, D
(*e*) A, D, C, B.

Sol. (*a*) The correct sequence is

1—C, 2—A, 3—D, 4—B.

20. For the past decade, a number of alternatives to petrofuels for road transport have been considered, such as alcohols, methane, syn fuel, solar photovoltaics, new generation storage batteries, fuel cells, hydrogen, etc. Of these, hydrogen appears to be most favoured alternative due to

(*a*) its high specific energy per unit weight
(*b*) its almost universal availability as a component of water
(*c*) good combustion characteristics
(*d*) its primary combustion product is water vapour and apart from low nitric oxide fractions, there are virtually no harmful exhaust gases
(*e*) all of above reasons.

Sol. (*e*) Though each reason given at (*a*) to (*d*) appears to be significant reason for favour of hydrogen as alternative fuel but all are equally important.

21. In designing the engine system to use hydrogen as fuel, the low ignition energy of the gas in air, the high lean burnability of a hydrogen/air mixture, the low octane number of hydrogen and low density of the gas poses following problem

(*a*) irregular combustion cycles due to back firing in the intake phases
(*b*) pre-ignition in the compression phase
(*c*) knocking during combustion and water accumulation at the spark plugs during cold start
(*d*) lower power density due to loss of volumetric efficiency
(*e*) all of the above.

Sol. (*e*) In fact, all the reasons at (*a*) to (*d*) pose problems in design of engine to use hydrogen as the fuel.

22. In order to use hydrogen for road transport engines, the hydrogen

(*a*) has to be compressed in cylinders and used after decreasing pressure
(*b*) stored in liquefied way
(*c*) use hydride-forming alloys which enable a low operating pressure of hydrogen
(*d*) generate hydrogen on-line
(*e*) any one of the above.

Sol. (*c*) Compressed hydrogen cylinders are not acceptable due to safety reasons. Liquefaction involves high energy consumption and is thus not recommended. On line generation is also not feasible.

Best method is to use certain metallic alloys which absorb hydrogen in an exothermic reaction when exposed to the gas and release this absorbed gas when heat is applied to the metal hydrides. For use in vehicles, the hydride fuel tank consists of a closely packed bundle of alloy tubes over which hydrogen gas is passed at a service station. Cooling water is used during the exothermic absorption reaction and hot exhaust gas for the endothermic gas release reaction.

23. The heat flow per unit length for steady conduction in a hollow cylinder of inside radius r_1, and outside radius r_2 is directly proportional to

$2\pi k(T_1 - T_2)$ and inversely proportional to $\{(k$ = thermalconductivity, T_1 and T_2 are temperatures inside and outside the sphere).

(*a*) $\frac{r_1 + r_2}{2}$ (*b*) $\sqrt{r_1 r_2}$

(*c*) $\log_{10} \frac{r_2}{r_1}$ (*d*) $\log_e \frac{r_2}{r_1}$

(*e*) $\log_e \frac{r_1}{r_2}$.

Sol. (*d*) Heat flow (q) through a hollow cylinder of length L is

$$\frac{q}{L} = \frac{2\pi k (T_1 - T_2)}{\log_e (r_2/r_1)}$$

24. The heat flow across a hollow sphere of inner radius r_1 and outer radius r_2 is proportional to

(a) $\frac{r_2 - r_1}{r_1 r_2}$ (b) $\frac{1}{\log_e r_2/r_1}$

(c) $\frac{r_1 + r_2}{r_1 \times r_2}$ (d) $\log_e \frac{r_2}{r_1}$

(e) $\frac{r_1 r_2}{r_2 - r_1}$.

Sol. (e) The heat flow across the spherical surface

$$= \frac{4\pi r_1 r_2 k}{r_2 - r_1}(T_1 - T_2)$$

(T_1 = temperature inside the sphere
T_2 = temperature outside the sphere
k = thermalconductivity.

25. Four types of radiation detectors to detect and measure radiant energy flux are found in common use. These are listed below.

Match the best description for them from the choices given below.

(1) Thermal Detectors — (A) These produce a voltage on absorption of incident radiation.

(2) Photoemissive Detectors — (B) These employ a sensitive element whose temperature rises on exposure to radiation

(3) Photoconductive Detectors — (C) When these semiconductor detectors are exposed to radiation, their electrical resistance decreases.

(4) Photovoltaic cells — (D) Light of proper frequency incident upon cathode causes the ejection of electrons which miagrate toward an anode resulting in current to flow.

(a) 1–B, 2–D, 3–C, 4–A (b) 1–B, 2–D, 3–A, 4–C
(c) 1–C, 2–B, 3–D, 4–A (d) 1–C, 2–D, 3–B, 4–A
(e) 1–B, 2–C, 3–A, 4–D

Sol. (a) The correct choice is 1–B, 2–D, 3–C, 4–A.

26. Fig. 9 shows a psychrometric chart. The constant lines represented by A_1, A_2, A_3 ; B_1, B_2, B_3 ; and C_1, C_2, C_3 etc. represent constant

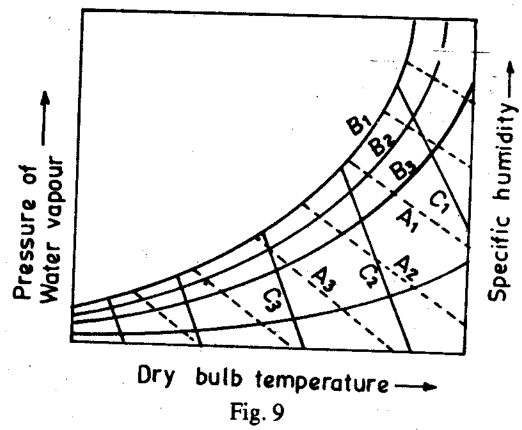


Fig. 9

(*a*) Relative humidity lines (RH), constant wet bulb temperature lines (WB), and constant volume lines (VOL)
(*b*) *WB, RH, VOL* (*c*) *VOL, RH, WB*
(*d*) *RH, VOL, WB* (*e*) *VOL, WB, RH.*

Sol. (*b*) The top most curve B_1 in Fig. 9 represents saturation line corresponding to 100% relative humidity. Lines moving along this line, *i.e.* B_2, B_3 etc. represent constant relative humidity lines. More sloping lines, *viz.* A_1, A_2, A_3 etc. are constant volume lines and dotted lines C_1, C_2, C_3 etc. represent constant wet bulb temperature lines.

27. Pick up wrong relationship in connection with viscosity and kinematic viscosity
(*a*) $1\ \text{Ns/m}^2 = 10$ poise (*b*) $1\ \text{cm}^2\text{/s} = 1$ stroke
(*c*) $1\ \text{m}^2\text{/s} = 1$ stroke (*d*) 1 Poise = 100 CP (Centipoise)
(*e*) 1 stoke = 100 CS (Centistoke)

Sol. (*c*) The correct relationship for $\text{m}^2\text{/s}$ and stoke is

$$1\ \text{m}^2\text{/s} = 10^4\ \text{stoke}$$

All other relationships at *a, b, d,* and *e* are correct.

28. Pick up wrong statement about surface tension of a liquid
(*a*) The surface tension of a liquid is expressed in dynes/cm^3
(*b*) The value of surface tension of a liquid depends on its temperature
(*c*) The value of surface tension of a liquid depends on its electrolytic content
(*d*) Small amounts of salt dissolved in water tend to increase the electrolytic content, and hence, surface tension
(*e*) Organic matter (such as soap) decreases the surface tension.

Sol. (*a*) The surface tension of a liquid is expressed in the units of force per unit length and hence its unit is dynes/cm. All other statements are correct.

29. A small amount of solvent is added to the ground water to change its electrolytic content. As a result, the contacting angle θ, representing the adhesion between water and soil material, is increased from 30° to 45°. If the soil has uniform pore size of 0.7 mm, the change in capillary rise in soil will be
(*a*) 50% rise (*b*) 41% rise
(*c*) 41% fall (*d*) 73% rise
(*e*) 73% fall.

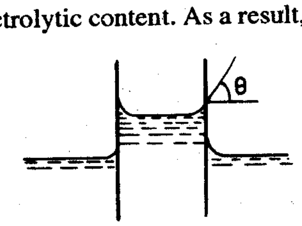


Fig. 10

Sol. (*b*) The rise/fall in capillary tube

$$h = \frac{4\sigma \sin\theta}{\rho D}$$

where
σ = surface tension
ρ = unit weight of liquid
D = inside diameter of tube bore
θ = angle at which the liquid film meets the glass

Since here θ changes from 30° to 45°,

$$h_2 - h_1 = \frac{4\sigma(\sin 45° - \sin 30°)}{\rho D}$$

∴ Percentage change in height

$$= \frac{\sin 45° - \sin 30°}{\sin 30°}$$

$$= \frac{0.707 - 0.5}{0.5} = \frac{0.207}{0.5} \cong 0.41$$

= 41% rise. (Rise is on account of + ve value)

30. The barge shown in Fig. 11 is 10 m long, 2.5 m wide and 2 m high, and weighs 196200 N. The minimum depth of the water way necessary to carry it will be

(*a*) 2 m (*b*) 1 m
(*c*) 0.8 m (*d*) 1.2 m
(*e*) 0.67 m.

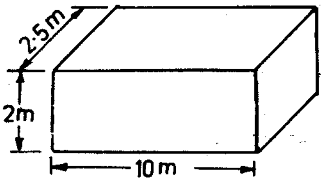


Fig. 11

Sol. (*c*) As the barge floats, the weight of water displaced by the barge equals the weight of the barge. Therefore, the minimum depth of the waterway is the submerged depth of the barge, h

$$\therefore \quad 196200 = 9810 \times 10 \times 2.5 \times h$$

and $$h = \frac{196200}{9810 \times 10 \times 2.5} = 0.8 \text{ m.}$$

31. One-seventh of an iceberg's mass is above the surface of the ocean. If specific weight of ice berg is 9000 N/m^3, the specific weight of the sea water is

(*a*) 1000 N/m^3 (*b*) 980 N/m^3
(*c*) 1010 N/m^3 (*d*) 1030 N/m^3
(*e*) 1050 N/m^3.

Sol. (*d*) If weight of iceberg is W, then by law of Archimedes,

$$W = V\rho_s$$

(ρ_s = density of seawater, V = volume of sea water displaced by the iceberg)

If the volume of iceberg $= V'$,

then its weight $W = V'\rho_i$ (ρ_i = density of iceberg)

Since $1/V$ of the iceberg is above the ocean surface,

$$\therefore \quad V\left(1 + \frac{1}{7}\right) = 1.143V = V'$$

$$\therefore \quad W = 1.143V\,(9000) = V\rho_s$$

and $$\rho_s = 1.143 \times 9000 = 1028.7 \text{ N/m}^3$$
$$\cong 1030 \text{ N/m}^3.$$

32. A floating wooden block 1 m wide, 1 m deep and 2 m long has the specific gravity such that the metacentre is at the same point as the centre of gravity (c.g.). The wooden block

(*a*) is stable (*b*) is unstable
(*c*) can be stable if c.g. is below the centre of buoyancy
(*d*) can be stable if c.g. is above the centre of buoyancy
(*e*) can be stable if c.g. coincides with centre of buoyancy in place of metacentre.

Sol. (*b*) It must be remembered that a floating body is stable only if the centre of gravity is below the metacentre, otherwise it is unstable. The question of c.g. relation with centre of buoyancy is applicable for a submerged body and not for the floating body. For submerged body to the stable, its c.g. should be below the centre of buoyancy.

33. Compute the dragging force on a raft having 20 sq. m area when it is dragged at a velocity of 1 m/sec in a shallow channel 0.1 m deep measured between the raft and the channel bottom. Take absolute viscosity of water as 1 centipoise at 20.2°C.

(*a*) 0.2 N (*b*) 0.02 N
(*c*) 2 N (*d*) 20 N
(*e*) 200 N.

Sol. (*c*) Viscous shear stress

$$\tau = \mu \frac{\Delta v}{\Delta y} \qquad (\mu = \text{absolute viscosity})$$

$\mu = 1$ centipoise $= 0.01$ poise

$= 0.01 \times \frac{1}{10}$ Ns/m^2

$= 0.001$ Ns/m^2

$\therefore \quad \tau = 0.001 \times \frac{1.0}{0.1} = 0.01$ N/m^2

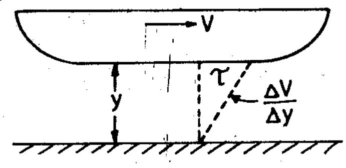


Fig. 12

$\therefore$ Dragging force $= \tau \times A = 0.01 \times 20 = 2$ N

34. In which of the following cases the value of resistance coefficient $K\,(fL/D)$ is maximum and minimum

(*a*) *B, C* (*b*) *E, C*
(*c*) *D, E* (*d*) *B, A*
(*e*) *A, B.*

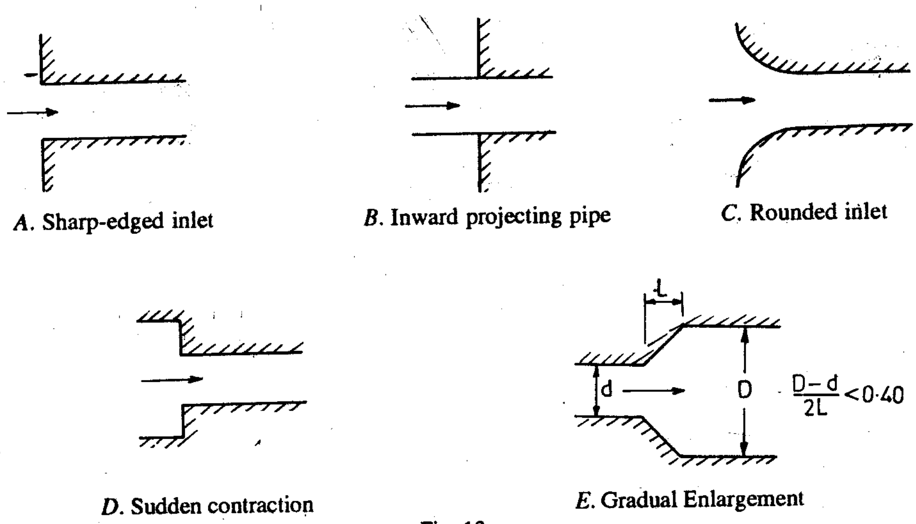


Fig. 13

Sol. (*a*) The values of resistance coefficient for various cases are as under

(*A*) 0.5 (*B*) 1.0
(*C*) 0.05 (*D*) 0.28 to 0.45 (depending on *D/p* from 1.5 to 4.0)
(*E*) 0.14 to 0.95 $\left(\text{depending on } \frac{D-d}{2L} \text{ from 0.05 to 0.4}\right)$.

35. Fig. 14 shows three entrance conditions of pipe into a large reservoir. The head loss at the entrance to a pipe can be expressed as $K_e \frac{V^2}{2g}$, where K_e = coefficient of loss of head at entrance.

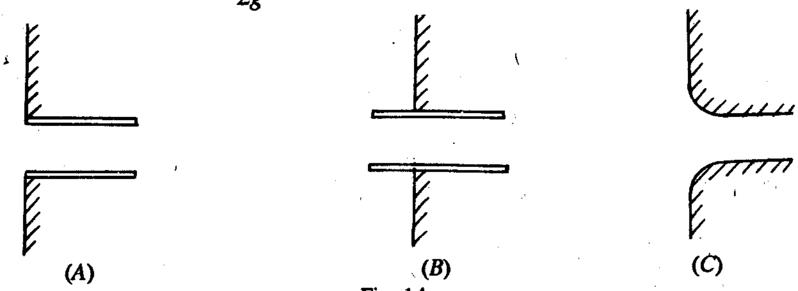


Fig. 14

The values of K_e in decreasing order are as under

(*a*) *A*, *B*, *C*
(*b*) *B*, *A*, *C*
(*c*) *C*, *A*, *B*
(*d*) *C*, *B*, *A*
(*e*) *B*, *C*, *A*.

Sol. (*b*) The value of K_e for case, *A*, *B*, and *C* respectively are 0.5, 0.8 and 0.04. Please note that minimum entrance losses are for (*C*) and maximum for (*B*).

36. Every valve and fitting in fluid flow line introduces resistance to flow. The resistance offered is expressed as equivalent length to pipe diameter (l/D) ratio. Arrange the following devices in decreasing l/D ratio.

(*A*) Gate valve fully open,
(*B*) 90° standard elbow,
(*C*) Globe valve fully open,
(*D*) Gate valve 25% open,
(*E*) Angle valve fully open.

(*a*) *D*, *C*, *E*, *B*, *A*
(*b*) *D*, *E*, *C*, *A*, *B*
(*c*) *B*, *C*, *E*, *A*, *D*
(*d*) *D*, *C*, *E*, *A*, *B*
(*e*) *C*, *D*, *B*, *A*, *E*.

Sol. (*a*) Typical values of l/D ratio are
Gate valve 25% open–900
Globe valve fully open–450
Angle valve fully open–200
90° standard elbow–30
Gate valve fully open–13.

Please try to appreciate the relative resistance offered by various valves and fittings to flow of fluid in pipeline.

37. In the passage of fluid from a reservoir to a pipe, over a square edge and non-re-entrant pipe inclined at angle θ as shown in Fig. 15, the coefficient of head loss

(*a*) $0.5 + 0.3 \cos\theta$
(*b*) $0.5 + 0.3 \cos\theta + 0.2 \cos^2\theta$
(*c*) $0.8 + 0.7 \cos\theta$
(*d*) $1 - 0.2 \cos\theta - 0.1 \cos^2\theta$
(*e*) $0.9 - 0.1 \cos\theta$.

Sol. (*b*) The correct relationship as given by Weisbach's formula is $k = 0.5 + 0.3 \cos\theta + 0.2 \cos^2\theta$.

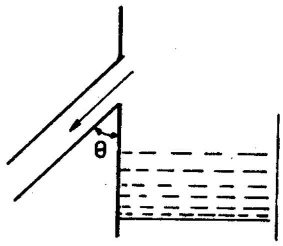


Fig. 15

38. A pitot tube is used to measure the velocity at a certain point in a water pipe. The differential pressure noted across pitot tappings is 1.962 kg/cm^2. The velocity of water in pipe is

(*a*) 1.962 m/s
(*b*) 19.62 m/s
(*c*) 9.81 m/s
(*d*) 4.905 m/s
(*e*) 3. 924 m/s.

Sol. (*b*) Velocity measured by pitot tube

$$= \sqrt{2gh}$$

h = differential pressure in m of water column

$$= 1.962 \times 10 = 19.62 \text{ m of } wcl$$

$$\therefore \quad V = \sqrt{2 \times 9.81 \times 19.62} = 19.62 \text{ m/s}.$$

39. Fig. 16 shows a venturimeter used for measurement of flow. Its coefficient of discharge is a function of

(*a*) A_1, A_2
(*b*) V_1, V_2, V_c
(*c*) α, β and A_1

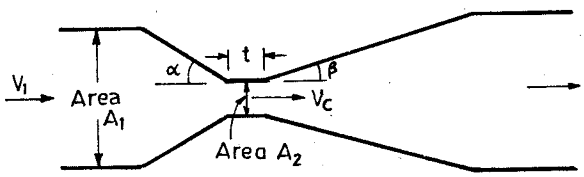


Fig. 16

(*d*) A_1, V_1, A_2, V_c, V_2
(*e*) α, β and A_2.

Sol. (*a*) Coefficient of discharge C_d of nozzle

$$= \frac{1}{\sqrt{(A_1/A_2)^2 - 1}}$$

$\therefore$ it is function of A_1 and A_2 only.

40. It takes 10 minutes to empty the contents of a prismatic tank through an orifice at the bottom of the tank. The time taken to empty first half will be

(*a*) 5 minutes
(*b*) 4 minutes
(*c*) 3 minutes
(*d*) 2.93 minutes
(*e*) 2.5 minutes.

Sol. (*d*) As the time elapses, the head (height of surface of water in the tank) varies parabolically. If h_1 and h_2 denote the head at beginning and end of a given time interval Δt, then $\Delta t = k(\sqrt{h_1} - \sqrt{h_2})$ (k = constant).

Let the initial head of tank = 1 unit

$$\therefore \quad h_1 = 1 \text{ and } h_2 = 0.5$$

$$\therefore \quad \frac{\Delta t}{10 \text{ min}} = \frac{1 - \sqrt{0.5}}{1 - 0} = 0.293$$

$$\therefore \quad \Delta t = 2.93 \text{ min.}$$

41. In filling a canal lock having a depth of 12 m, it was observed that it required 2 minutes for the water surface to rise to a 3 m depth. How much additional time is required for the surface to rise to an 8 m depth

(*a*) 4.32 min
(*b*) 3.33 min
(*c*) 4 min
(*d*) 5 min
(*e*) 6 min.

Sol. (*a*) For initial interval, $h_1 = 12$ m, $h_2 = 12 - 3 = 9$ m.

For the second interval, $h_1 = 9$ m, $h_2 = 12 - 8 = 4$ m

$$\therefore \quad \frac{\Delta t}{2 \text{ min}} = \frac{\sqrt{9} - \sqrt{4}}{\sqrt{12} - \sqrt{9}} = 2.16$$

$$\therefore \quad \Delta t = 4.32 \text{ min.}$$

42. The friction head loss in a pipe flow is proportional to

(*a*) $\frac{1}{D}$ (D = Inside diameter of pipe)

(*b*) $\frac{1}{D^2}$
(*c*) $\frac{1}{D^3}$
(*d*) $\frac{1}{D^4}$
(*e*) $\frac{1}{D^5}$.

Sol. (*e*) The friction loss in a pipe flow

$$h_f = f\frac{L}{D}\cdot\frac{V^2}{2g}$$

(L = length, V = velocity, f = friction factor)

$$V = \frac{Q}{A} = \frac{4Q}{\pi D^2}$$

$$\therefore \quad h_f = f\cdot\frac{L}{D}\cdot\frac{\left(\frac{4Q}{\pi D^2}\right)^2}{2g}$$

$$= f\cdot\frac{L}{D}\cdot\frac{16Q}{\pi^2\cdot 2g}\cdot\frac{1}{D^4} \propto \frac{1}{D^5}.$$

43. In the case of laminar flow, the friction factor f is independent of the relative roughness and is only a function of the Reynolds number R_e. f is proportional to

(*a*) R_e (*b*) $\frac{1}{R_e}$

(*c*) $\left(\frac{1}{R_e}\right)^2$ (*d*) $\left(\frac{1}{R_e}\right)^{3/2}$

(*e*) $\frac{1}{\sqrt{R_e}}$.

Sol. (*b*) For laminar flow $f = \frac{64}{R_e}$.

44. Which of the following is Cipolletti weir

(*a*) uncontracted horizontal weir
(*b*) contracted horizontal weir
(*c*) V-notched weir
(*d*) trapezoidal weir with inclined side at 45°
(*e*) trapezoidal weir having horizontal crest and the sides inclined outwardly at a slope of 1 (horizontal) to 4 (vertical).

Sol. (*e*) Fig. 17 shows the shape of Cipolletti weir which is described by (*e*). The height of the weir crest should be at least twice the head of the approach flow above the bottom, and the distances from the sides of the notch to the sides of the channel should also be at least twice the head.

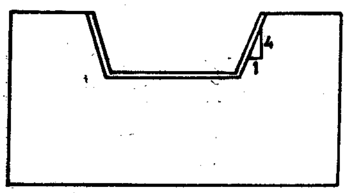


Fig. 17

45. Fig. 18 (*a*) and (*b*) shows the behaviour of depth of flow with time in the case of flood wave and tidal surge.

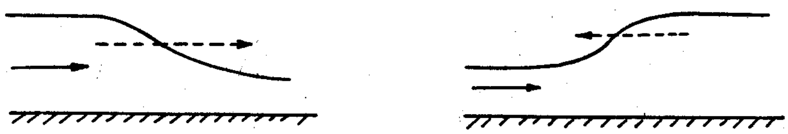

(*a*) Flood wave (*d*) Tidal surge

Fig. 18

These are the cases of

(*a*) steady flow
(*b*) uniform flow
(*c*) varied steady flow
(*d*) varied unsteady flow
(*e*) unsteady uniform flow.

Sol. (*d*) It may be noted that in a steady flow the discharge and water depth at any section in the reach do not change with time during the period of interest. Therefore (*a*) is false.

In uniform flow the discharge and the water depth remain the same in every section in the channel reach. Therefore (*b*) is also false. Further a varied flow in open channel is one in which the water depth and/or the discharge change along the length of channel, and the change is gradual in case of varied steady flow. Thus (*c*) is also false. (*d*) is correct because in varied unsteady flow the depth changes abruptly. (*e*) is false because uniform flows are mostly steady.

46. In uniform channel flow, if the hydraulic radius be increased from 8 m to 27 m, the flow will change by

(*a*) 27/8 times (*b*) $\sqrt{27/8}$ times
(*c*) 1.5 times (*d*) twice
(*e*) 2.25 times.

Sol. (*e*) In the case of uniform open channel flow,

$$Q \propto R_H^{2/3} \qquad (R_H = \text{hydraulic radius})$$

$$\therefore \quad \frac{Q_2}{Q_1} = \left(\frac{27}{8}\right)^{2/3} = \frac{9}{4} = 2.25.$$

47. The best hydraulic section in case of open channel is the one with least wetted perimeter. The semicircular cross-section channel is the most hydraulically efficient out of all sections. But due to its high initial cost and high maintenance cost, it is not used and next choices are for rectangle and trapezoidal sections.

Most efficient rectangular open channel section and most efficient trapezoidal open channel sections are

(*a*) half-square section, and half-hexagon sections
(*b*) 5/8-square section, and with slopes of 30°
(*c*) 3/8-square section, and with slopes of 45°
(*d*) 7/8-square section, and with slopes of 60°
(*e*) half-square section, and with slopes of $67\frac{1}{2}$°.

Sol. (*a*) The most efficient rectangular section is the half-square section which can be inscribed to a semicircle with centre of the circle at the free water surface. The most efficient trapezoidal section is a half-hexagon which can be inscribed to a semicircle with its centre at the free water surface and 60° angle on the sides.

48. Fig. 19 shows the specific energy curve versus depth of flow for a given discharge in an open channel. The correct curve is represented by curve

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) *E*.

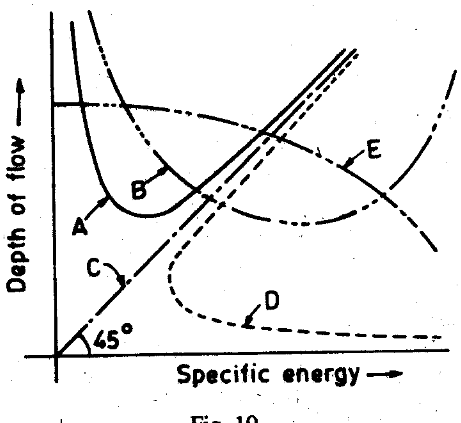


Fig. 19

Sol. (*d*) The specific energy curve for open channel flow comprises of two limbs. The lower limb always approaches the horizontal axis toward the right and the upper limb approaches asymptotically to the 45° line that passes through the origin. The correct curve as per above is *D*.

49. A 3 m wide rectangular channel carries 15 m^3/sec of water. Its critical depth is equal to

(*a*) 1 m
(*b*) 1.5 m

(*c*) 1.6 m (*d*) 2 m
(*e*) 3 m.

Sol. (*c*) The critical depth in case of open channel flow

$$d_c = \sqrt[3]{\frac{q^2}{g}}$$

g = discharge per unit width
$= 15/3 = 5 \text{ m}^3/\text{sec/m}$

$$\therefore \quad d_c = \sqrt{\frac{5^2}{9.81}} = 1.60 \text{ m}.$$

50. Tick the odd person out
(*a*) Moody (*b*) Chezy
(*c*) Darcy (*d*) Manning
(*e*) Froude.

Sol. (*e*) Persons at (*a*) to (*d*) are concerned with pipes and friction losses for which Froude has done no work.

51. In engineering, one comes across several numbers. The table below gives the significance and field of use of some commonly used numbers, arranged in distorted way

Name of number	*Significance and filed of use*
1. Weber number	(*a*) Viscous force/load force (lubrication)
2. Truncation number	(*b*) Heat transferred/thermal capacity of fluid (forced convection)
3. Thoma number	(*c*) Net positive suction head/total head (cavitation in pumps)
4. Stanton number	(*d*) Shear stress/normal stress (viscous flow)
5. Sommerfeld number	(*e*) Inertia force/surface tension force (Bubble formation)

The correct sequence for 1, 2, 3, 4 and 5 respectively is
(*a*) *A, C, D, B, E* (*b*) *E, D, C, B, A*
(*c*) *D, E, B, C, A* (*d*) *E, D, B, C, A*
(*e*) *C, D, E, A, B.*

Sol. (*b*) The correct combination is

1—*E*, 2—*D*, 3—*C*, 4—*B*, 5—*A*.

52. A geometrically similar open channel model is constructed with a 5 : 1 scale. If the model measures a discharge of 0.2 m³/s, the corresponding discharge in prototype is
(*a*) 1 m³/s (*b*) 5 m³/s
(*c*) 25 m³/s (*d*) 125 m³/s
(*e*) none of the above.

Sol. (*c*) The velocity ratio of prototype (*p*) and model (*m*) is

$$\frac{V_p}{V_m} = \frac{L_p/T}{L_m/T} \cdot \frac{L_p}{L_m} = 5$$

(Time in model and prototype remains unchanged)
Area ratio between *p* and *m* is

$$\frac{A_p}{A_m} = \frac{L_p^2}{L_m^2} = 25$$

Discharge ratio $= \frac{Q_p}{Q_m} = \frac{A_p V_p}{A_m V_m} = 25 \times 5 = 125$

∴ Corresponding discharge in prototype

$$= Q_p = 125\, Q_m = 125 \times 0.2 = 25 \text{ m}^3/\text{s}.$$

53. Pick out the false statement about similarity relations for centrifugal pumps (Q = flow, N = speed, D = diameter, P = power).

(a) $\frac{Q_1}{N_1D_1^{\ 2}} = \frac{Q_2}{N_1D_2^{\ 3}}$ (b) $\frac{H_1}{(N_1D_1)^2} = \frac{H_2}{(N_2D_2)^2}$

(c) $\frac{P_1}{N_1^{\ 3}D_1^{\ 5}} = \frac{P_2}{N_2^{\ 3}D_2^{\ 5}}$ (d) $\frac{P_1}{Q_1H_1} = \frac{P_2}{Q_2H_2}$

(e) $\frac{H_1}{Q_1/D_1^{\ 2}} = \frac{H_2}{Q_2/D_2^{\ 2}}$.

Sol. (e) All relations except (e) are corrected.

For (e) correct relationship is $\frac{H_1}{(Q_1/D_1^{\ 2})^2} = \frac{H_2}{(Q_2/D_2^{\ 2})^2}$.

54. A centrifugal pump delivers 1000 litres per minute at 2000 rpm against a total dynamic head of 50 m and requires 32 bhp for its operation. If speed is reduced to 1000 rpm, the discharge, head developed, and brake horse power required will be

(a) 500 l/mt, 12.5 m, 4 bhp (b) 500 l/mt, 25 m, 16 bhp
(c) 500 l/mt, 12.5 m, 8 bhp (d) 250 l/mt, 125 m, 8 bhp
(e) 250 l/mt, 12.5 m, 4 bhp.

Sol. (a)

$$Q_1 = 1000 \text{ l/mt}, \ H_1 = 50 \text{ m}, \ P_1 = 32 \text{ bhp}$$

$$Q_2 = Q_1 \times \frac{N_2}{N_1} = 1000 \times \frac{1}{2} = 500 \text{ l/mt}$$

$$\frac{N_2}{N_1} = \frac{1000}{2000} = \frac{1}{2}$$

$$H_2 = H_1 \times \left(\frac{N_2}{N_1}\right)^2 = 50 \times \frac{1}{4} = 12.5 \text{ m}$$

$$P_2 = P_1 \times \left(\frac{N_2}{N_1}\right)^2 = 32 \times \frac{1}{8} = 4 \text{ bhp.}$$

55. Fig. 20 shows the range of typical applications of centrifugal propeller positive displacement, and jet (mixed flow) pumps. The relative regions for their operation are

(a) A, B, C, D (b) D, C, B, A
(c) C, A, B, D (d) C, A, D, B
(e) A, B, D, C.

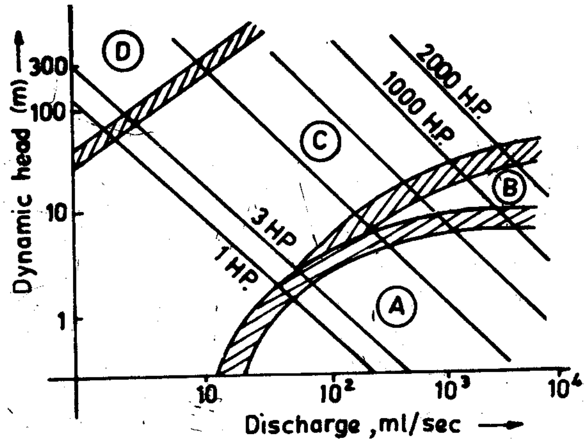


Fig. 20

Sol. (*d*) It may be remembered that positive displacement pumps are used for low discharge and high dynamic head; propeller pumps for high discharge and low dynamic head. The range of operation of jet pumps is in between propeller and centrifugal pumps. The centrifugal pumps are used for wide range of applications.

56. Pick up false statement about centrifugal pumps.

(*a*) Specific speed is defined as $N_s = \frac{N\sqrt{Q}}{H^{3/4}}$,

(N = pump RPM, Q = discharge, H = head)

(*b*) Specific speed is defined as

$$N_s = \frac{N\sqrt{P}}{H^{5/4}} \ (P = \text{shaft power})$$

(*c*) Centrifugal pumps with identical geometric proportions but different sizes have the same specific speed

(*d*) pumps with high specific speeds are used for large discharges at high pressure heads

(*e*) pumps with low specific speeds are used to deliver small discharge at high pressure heads.

Sol. (*d*) It may be noted that specific speed of centrifugal pumps can be defined in two different ways (in terms of discharge and in terms of power); so both (*a*) and (*b*) are correct. Statement at (*c*) and (*e*) are correct. The statement at (*d*) is false because pumps with high specific speeds are used for large discharges at low-pressure and not at high pressure.

57. The discharge of compressed air in pipe, when there is a comparatively small difference of pressure at the two ends of the pipe, is proportional to

(*a*) $\sqrt{\frac{\Delta p a^5}{\rho L}}$

(*b*) $\sqrt{\frac{\Delta p a^3}{\rho L}}$

(ΔP = difference in pressure at two ends of pipe
d = inside diameter of pipe
ρ = density of entering air
L = length of pipe)

(*c*) $\Delta P\sqrt{\frac{d}{\rho L}}$

(*d*) $\Delta P\sqrt{\frac{d^3}{\rho^2 L^5}}$

(*e*) $\Delta P\sqrt{\frac{d}{\rho L^3}}$.

Sol. (*a*) The correct relationship is $Q = \sqrt{\frac{\Delta P d^5}{\rho L}}$.

58. In industry, it is often required to control volume of air delivery by fans. Fig. 21 shows the effectiveness of various methods of controlling the same

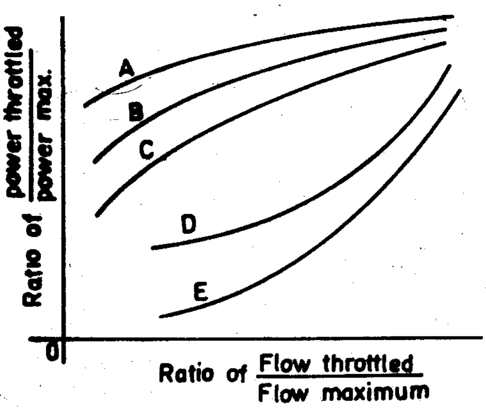


Fig. 21

The curves applicable for
(1) variable speed drive,
(2) outlet damper control,
(3) variable pitch blade,
(4) inlet vanes, and
(5) inlet damper are.

(*a*) *A, B, C, D, E* (*b*) *E, D, C, B, A*
(*c*) *E, A, D, C, B* (*d*) *E, A, C, D, B*
(*e*) *E, B, C, D, A*.

Sol. (*c*) The variable speed drive is the most effective method as it generates the desired flow and not much throttling is involved (curve *E*).

Next efficient method is variable pitch blade, which also causes lesser throttling (curve *D*).

Inlet vanes (*C*) offer resistance but lesser than the inlet damper (*B*) and outlet damper (*A*) methods of control.

Thus the correct sequence is

1–E, 2–A, 3–D, 4–C, 5–B.

59. Fig. 22 shows a column-100 sq-cm in cross-sectional area. Angle clips are welded to the column to support the loads as shown. The axial stresses at section *AA*, *BB*, and *CC* respectively in kg/cm^2 are

(*a*) 40, 60, 120 (*b*) 20, 30, 60
(*c*) 40, 40, 40 (*d*) 89, 120, 240
(*e*) 12, 120, 120.

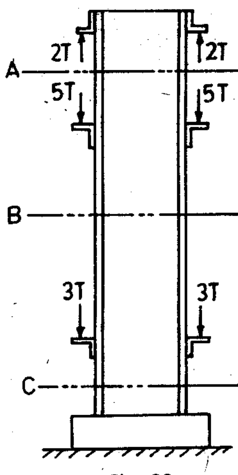


Fig. 22

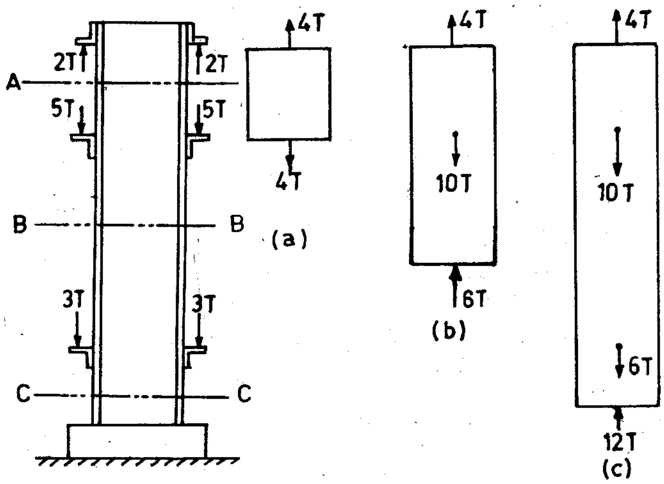


Fig. 23

Sol. (*a*) The free body diagrams for section *AA*, *BB*, *CC* are shown in Fig. 23 (*a*), (*b*) and (*c*)

Stress at $AA = \dfrac{4 \times 1000}{100} = 40 \text{ kg/cm}^2$

Stress at $BB = \dfrac{6 \times 1000}{100} = 60 \text{ kg/cm}^2$

Stress at $CC = \dfrac{12 \times 1000}{100} = 120 \text{ kg/cm}^2$.

60. A bar of uniform cross-section and homogeneous material weighing 1,000 N and having cross-section of 1 cm^2 and length 1 m, hangs vertically while suspended from one end. Value of $E = 10{,}000 \text{ N/mm}^2$. The extension of bar due to its own weight will be

(*a*) 1 mm (*b*) 0.5 mm
(*c*) 2 mm (*d*) 0.25 mm
(*e*) 0.75 mm.

Sol. (*b*) Deflection of a bar by its own weight

$$= \frac{WL}{2AE}$$

$(A = 1\text{ cm}^2 = 10 \times 10 = 100\text{ mm}^2,\ L = 1\text{ m} = 1000\text{ mm})$

$$= \frac{1000 \times 1000}{2 \times 100 \times 10000} = 0.5\text{ mm}.$$

61. For a given matérial the modulus of rigidity is 10000 N/mm² and Poisson's ratio is 0.25. The value of modulus of elasticity will be
(*a*) 20000 N/mm² (*b*) 12500 N/mm²
(*c*) 15000 N/mm² (*d*) 25000 N/mm²
(*e*) 40000 N/mm².

Sol. (*d*) Modulus of elasticity $E = 2(1 + \mu)G$

μ = Poisson's ratio = 0.25

G = modulus of rigidity = 10000 N/mm²

$$\therefore \quad E = 2(1 + 0.25) \times 10000 = 2.5 \times 10000 = 25000\text{ N/mm}^2.$$

62. For an incompressible material, the value of Poisson's ratio is
(*a*) 1 (*b*) 0
(*c*) 0.5 (*d*) ∞
(*e*) 0.333.

Sol. (*c*) The correct answer for the Poisson's ratio value of incompressible material is 0.5 and it represents the maximum value possible. All practical materials have value less than 0.5.

63. If the Poisson's ratio is 0.25, then the ratio of the shear modulus to the elastic modulus is
(*a*) 0.4 (*b*) 0.25
(*c*) 0.5 (*d*) 1.25
(*e*) 1.4.

Sol. Modulus of rigidity *G*, and modulus of elasticity *E*, are related as

$$G = \frac{E}{2(1+\mu)} \qquad (\mu = \text{Poisson's ratio})$$

$$\therefore \quad \frac{G}{E} = \frac{1}{2(1+0.25)} = \frac{1}{2 \times 1.25} = \frac{1}{2.5} = 0.4.$$

64. The block shown in Fig. 24 is subjected to a shear force causing the deformation δW as shown. The shearing strain is equal to
(*a*) $\frac{\delta W}{W}$ (*b*) $\frac{\delta W}{L}$
(*c*) $\frac{\delta W}{F}$ (*d*) $\delta W \times \frac{W}{L}$
(*e*) $\delta W \times \frac{F}{W}$.

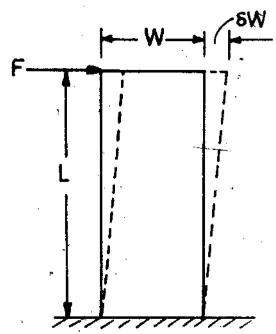


Fig. 24

Sol. (*b*) By definition, shearing strain = $\delta W/L$.

65. A steel band-saw blade 20 mm wide and 1 mm thick is driven by two, 1 m diameter pulleys as shown in Fig. 25. The maximum stress developed in the blade is equal to

(*a*) 1000 kg/cm^2 (*b*) 500 kg/cm^2
(*c*) 1500 kg/cm^2 (*d*) 2500 kg/cm^2
(*e*) 2000 kg/cm^2.

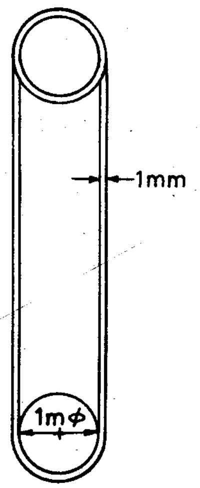


Fig. 25

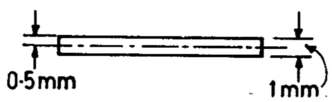


Fig. 26

Sol. (*e*) Flexural stress in blade = EC/R

(where $E = 2 \times 10^6$ kg/cm^2 for steel
$C = 0.5$ mm $= 0.05$ cm
$R = \frac{1}{2}$ m $= 50$ cm)

$$= \frac{2 \times 10^6 \times 0.05}{50} = 2000 \text{ kg/cm}^2.$$

66. Steel rope and aluminium rope of same cross-section are used to support a uniformly distributed load W from two ends as shown in Fig. 27. In order to keep the beam horizontal, the ratio of length of steel to aluminium wires should be (Ratio of coefficient of elasticity of steel and aluminium is 3)

(*a*) 3 (*b*) $\frac{1}{3}$
(*c*) 9 (*d*) $\sqrt{3}$
(*e*) 3/2.

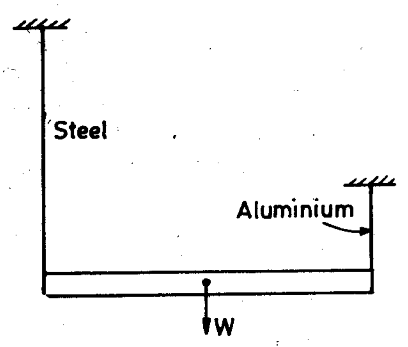


Fig. 27

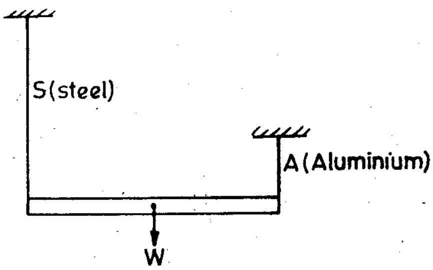


Fig. 28

Sol. (*a*) For the beam to remain horizontal, the deflection of steel and aluminium ropes should be same *i.e.*

$$\delta_S = \delta_A$$

or

$$\left(\frac{FL}{EA}\right)_S = \left(\frac{FL}{EA}\right)_A$$

(Due to uniformly distributed load, $F_S = F_A = W/2$)

$$\frac{L_S}{L_A} = \frac{E_S}{E_A} = 3$$

67. Two pieces of steel are solidly welded along a plane inclined at 30° as shown in Fig. 29 to form a rectangular bar of cross-section 25 cm^2. If the normal stress and shearing stress are not to exceed 500 kg/cm^2 and 250 kg/cm^2, respectively, the maximum safe load that can be carried by bar is

(*a*) 50,000 kg (*b*) 25,000 kg
(*c*) 28,868 kg (*d*) 14,434 kg
(*e*) 7,217 kg.

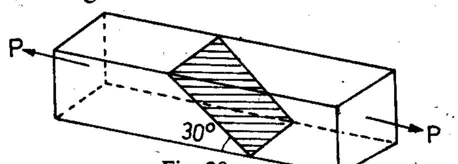


Fig. 29

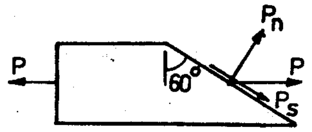


Fig. 30

Sol. (*d*) Free body diagram is as shown in Fig. 30.

Two values of P need to be computed, one based on allowable normal stress and other on allowable shearing stress. Smaller of these two is the permissible design load P.

Now $P_n = P\cos\theta$

and $P_s = P\sin\theta$

also A' = Area of oblique plane

$$= \frac{A}{\cos\theta} \qquad (A = \text{area of cross-section of bar})$$

$\therefore$
$$s_t = \frac{P_n}{A'} = \frac{P\cos\theta}{A/\cos\theta} = P\cos^2\theta \qquad ...(1)$$

and
$$S_n = \frac{P_s}{A'} = \frac{P}{A}\sin\theta\cos\theta$$

$$= \frac{P}{2A}\sin 2\theta \qquad ...(2)$$

From Eq. (1),
$$P_1 = \frac{s_t \times A}{\cos^2\theta} = \frac{500 \times 25}{\cos^2 60°} = 50000\text{ kg}$$

From Eq. (2),
$$P_2 = \frac{2s_s A}{\sin 2\theta} = \frac{2 \times 250 \times 25}{\sin 120°} = 14434\text{ kg}.$$

68. Fig. 31 shows the stresses acting on a point in a structural member. The radius of Mohr's circle to determine the magnitude and orientation of the principal stresses would be equal to

(*a*) 60 MPa (*b*) 120 MPa
(*c*) 70 MPa (*d*) 110 MPa
(*e*) 55 MPa.

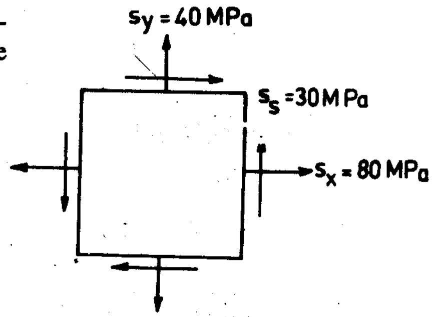


Fig. 31

Sol. (*a*) The radius of Mohr's circle

$$= \tfrac{1}{2}(s_x + s_y) = \tfrac{1}{2}(40 + 80) = 60\text{ MPa}.$$

69. If the stress applied to a member is doubled, the elastic strain energy will

(a) be doubled (b) be four times
(c) be eight times (d) be half of earlier value
(e) be same.

Sol. (b) Elastic strain energy is given as

$$\text{Volume} \times \frac{\text{Stress}^2}{2E}$$

Since it is proportional to square of stress, it will become four times than earlier value.

70. If the area, length and the stress to which a bar is subjected be all doubled, then the elastic strain energy of the bar will be

(a) doubled (b) halved
(c) four times (d) eight times
(e) sixteen times.

Sol. (d) Strain energy $= AL\left(\frac{s^2}{2E}\right)$

Since A, L and s are doubled,

$\therefore$ New strain energy $= 2A \times 2L \times \left(\frac{2s}{2E}\right)^2$

$$= 8AL\frac{s^2}{2E}$$

$$= 8 \times \text{original value.}$$

71. The total angle of twist of the stepped shaft shown in Fig. 32 is equal to

(a) $\frac{32TR}{\pi Gd^4}$ (b) $\frac{64Tl}{\pi Gd^4}$

(c) $\frac{16Tl}{\pi Gd^4}$ (d) $\frac{66Tl}{\pi Gd^4}$

(e) $\frac{68Tl}{\pi Gd^4}$.

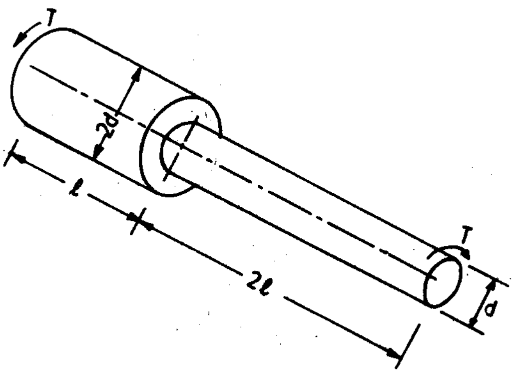


Fig. 32

Sol. (d) Total angle of twist = Sum of twist of two portions

$$= \frac{32Tl}{2G(2d)^4} + \frac{32T \times 2l}{piGd^4} = \frac{32Tl}{\pi Gd^4}\left(\frac{1}{16} + 2\right)$$

$$= \left(\frac{32Tl}{\pi Gd^4}\right)\frac{33}{16} = \frac{66Tl}{\pi\, Gd^4}$$

72. For a shaft delivering power of P kW at N RPM, the twisting moment T is proportional to

(a) N (b) N^2
(c) $1/N$ (d) $1/N^2$
(e) $1/\sqrt{N}$.

Sol. (c) Twisting moment $T = \frac{9.55 \times 10^6 P}{N}$

where T is in N-mm
P is power is kW
N is R.P.M.

$$T \propto \frac{1}{N}$$

73. For main power transmitting shafts transmitting power P kW at N r.p.m., the diameter D is proportional to

(a) $\frac{P}{N}$ (b) $\sqrt{\frac{P}{N}}$
(c) $\sqrt[3]{\frac{P}{N}}$ (d) $\left(\frac{P}{N}\right)^{2/3}$
(e) $\sqrt[4]{\frac{P}{N}}$.

Sol. (c) For main power-transmitting shaft

$$P \propto D^3 N$$

or $$D \propto \left(\frac{P}{N}\right)^{1/3}$$

74. What power would a short shaft, 50 mm in diameter, transmit at 400 r.p.m.

(a) 60 kW (b) 20 kW
(c) 40 kW (d) 30 kW
(e) 120 kW.

Sol. (a) For small, short shafts

$$P = \frac{D^3 N}{0.83 \times 10^6} \quad (D = \text{dia. in mm}, N = \text{RPM})$$

$$= \frac{50^3 \times 400}{0.83 \times 10^6} = 60 \text{ kW}.$$

75. Fig. 33 shows an elliptical shaft. It is required to transmit a torque T. The maximum shear stress will occur at

(a) A, A (b) B, B
(c) C, C (d) D, D
(e) E, E.

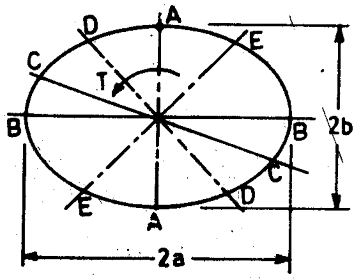


Fig. 33

Sol. (a) The value of maximum shearing stress at A, A is $2T/\pi ab^2$ and at B, B is $2T/\pi a^2 b$.

$\therefore$ Maximum shearing occurs at A, A and its value is $2T/\pi ab^2$.

76. A rectangular bar of height 10 cm and thickness 1 cm is subjected to a torsion value of 1000 Nm. The maximum shear stress induced is equal to

(a) 10 Nm (b) 100 Nm
(c) 300 Nm (d) 20 Nm
(e) 30 Nm.

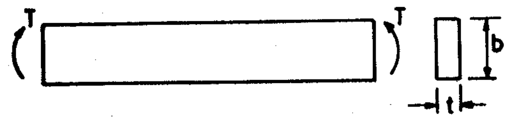


Fig. 34

Sol. For rectangular bar subjected to torsion having

$$\frac{b}{t} \geq 10$$

$$s_s = \frac{3T}{bt^2}$$

$$= \frac{3 \times 1000 \times 10}{10 \times 1^2} = \text{N cm} = 3000 \text{ N cm} = 30 \text{ N-m}.$$

77. The five cross-sectional areas shown in Fig. 35 are each axially strained 0.001 mm per mm. The axial deformations in these will be as follows

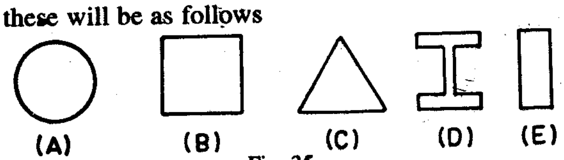


Fig. 35

(*a*) $\delta_A > \delta_B > \delta_C > \delta_D > \delta_E$
(*b*) $\delta_C > \delta_E > \delta_B > \delta_A > \delta_D$
(*c*) $\delta_D > \delta_E > \delta_C > \delta_B > \delta_A$
(*d*) $\delta_C > \delta_B > \delta_A > \delta_E > \delta_D$
(*e*) $\delta_A = \delta_B = \delta_C = \delta_D = \delta_E$.

Sol. (*e*) Since strain produced in the five cross-sectional areas is same, the cross-section must be constant. Therefore the axial deformation in each case will be same.

78. Fig. 36 shows six fundamental methods of supporting beam. Which cases fall under the category of statically indeterminate beams

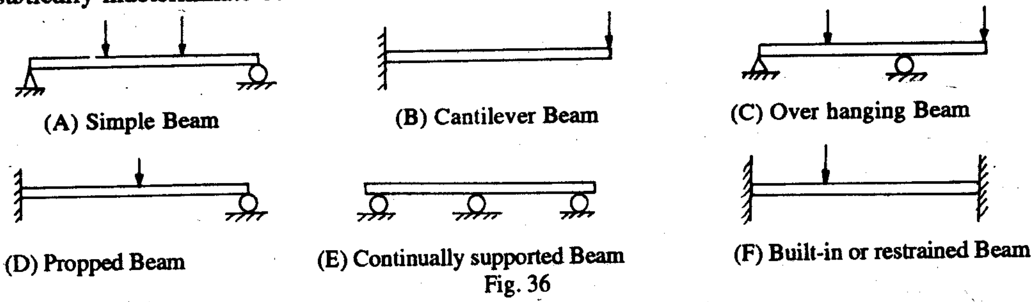


Fig. 36

(*a*) *A, B, C*
(*b*) *C, D, E*
(*c*) *B, C, D*
(*d*) *D, E, F*
(*e*) *C, E, F.*

Sol. (*d*) Statically indeterminate beams are those which have more supports than are necessary to maintain equilibrium. Propped beam, continually supported, and built-in beams fall under this category.

79. The bending moment diagram for the loadings shown in four cases below (Fig. 37) respectively will be

(*a*) rectangle, triangle, parabola, cubic parabola
(*b*) triangle, rectangle, cubic parabola, parabola
(*c*) triangle, parabola, rectangle, cubic parabola
(*d*) rectangle, parabola, triangle, cubic parabola

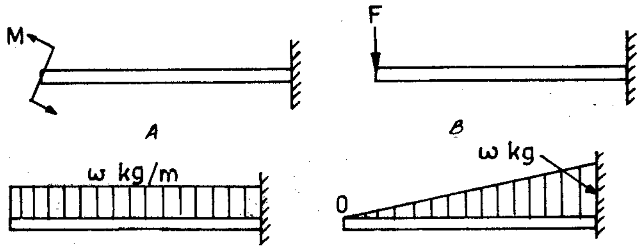


Fig. 37

(e) rectangle, triangle, cubic parabola, parabola.

Sol. (a) In case A, the bending moment is acting at end and is transmitted uniformly throughout the length and thus BM diagram will be rectangle.

In case B, concentrated load acts at the end which will produce linearly increasing BM, as the length increases, and thus BM diagram is a triangle.

In case C, uniformly distributed load is applied and BM diagram is a function of both the length and the square of length and thus BM diagram is a parabola.

In case D, the load is of variable nature and it will result into BM of cubic parabola type.

80. Fig. 38 (a) shows a statically determinate beam. If loading is reversed as in Fig. 38 (b), then reactions R_1, R_2, and R_3 will be

(a) 100, 100, 100 (b) 150, 0, 150

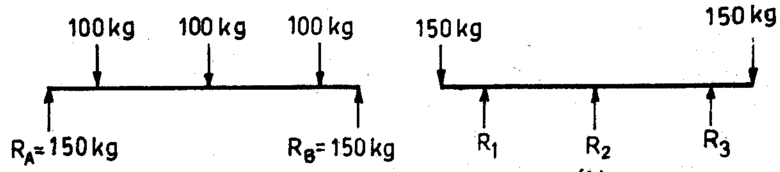


Fig. 38

(c) 75, 150, 75 (d) 50, 200, 50

(e) none of the above.

Sol. (e) In fact the case shown in Fig. 38 (b) becomes statically indeterminate as there are more supports than necessary and thus an infinite number of answers are possible.

81. If the load applied on a cantilever beam is doubled, alongwith its length and moment of inertia also, then the deflection at free end will increase

(a) 2 times (b) 4 times

(c) 8 times (d) 16 times

(e) $2\sqrt{2}$ times.

Sol. (c) For a cantilever, $\delta_1 = \frac{PL^3}{3EI}$

$$\delta_2 = \frac{2P \times (2L)^3}{3E \times 2I} = \frac{8PL^3}{3EI}$$

∴ New deflection is 8 times the earlier value.

82. Fig. 39 shows a cantilever beam carrying a uniformly distributed load $W = wL$. Five diagrams below it show shear diagram, moment diagram, deflection diagram, load diagram, slope diagram. These are shown in above order by

(a) A, B, C, D, E (b) B, C, E, A, D

(c) D, C, E, A, B (d) B, C, A, E, D

(e) B, C, D, A, E.

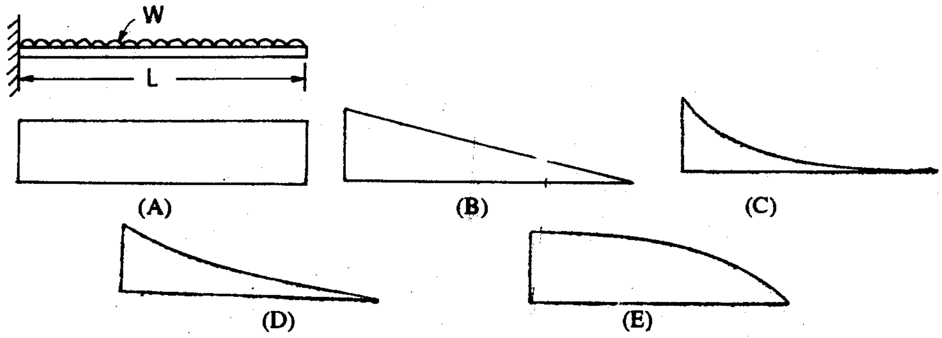


Fig. 39

Sol. (*b*) Fig. 40 shows how various parameters are arrived at. Shear S acting at any section = total load on right of section

$$= \int w dx.$$

Since shear $S = \frac{dM}{dx}$,

$\therefore$ $M = \int S dx.$

Further $M = EI \frac{d^2 f}{dx^2}$

$\therefore$ $\int M dx = EI\left[\left(\frac{df}{dx} + C\right)\right] = EI(i + C)$

(C = constant of integration)

and i = slope or grade of the elastic curve

$i = \text{slope} = \int M dx$

deflection $f = \int i dx$

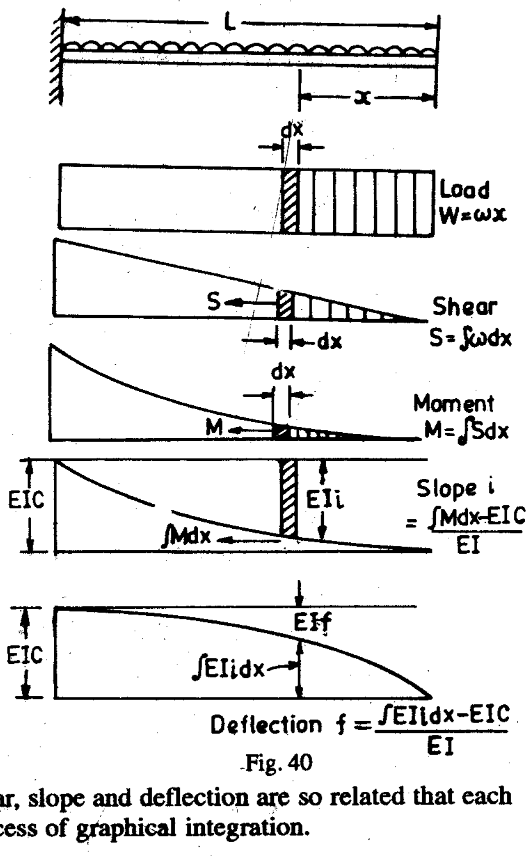


Fig. 40

It may be noted that the five curves of load, shear, slope and deflection are so related that each curve is derived from the previous one by a process of graphical integration.

83. In the case of a square flat plate of 1 cm thickness supported at top and bottom of all four edges and a uniformly distributed load of 10^5 Newtons over the surface of plate will be subjected to maximum tensile stress of

(*a*) 2.9×10^2 N/mm^2 (*b*) 2.9×10^3 N/mm^2
(*c*) 2.8×10^2 N/mm^2 (*d*) 3.9×10^2 N/mm^2
(*e*) 2.4×10^2 N/mm^2.

Sol. (*a*) For a square flat of thickness "*t*", supported at top and bottom of all four edges and carrying a uniformly distributed load W over the surface of the plane experiences a maximum tensile stress

$$= \frac{0.29W}{t^2} = \frac{0.29 \times 10^5}{10^2} = 2.9 \times 10^2 \text{ Newtons.}$$

84. The reaction at *A* (left support) in Fig. 41 will be

(*a*) $wL/2$ (*b*) $wL/3$

(*c*) $\frac{3}{4}wL$ (*d*) $\frac{3}{8}wL$

(*e*) $\frac{2}{3}wL$.

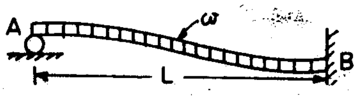


Fig. 41

Sol. (*d*) Let us remove the left support and treat the force *R* at left support as an applied load [Refer Fig. 42 (*b*)]. We now have an ordinary cantilever beam sustaining a uniform load and a concentrated load at its free end. Fig. 42 (*a*) and (*b*) show the elastic curves with the two loads acting non-synchronously.

(*a*) (*b*)

Fig. 42

Thus $y_1 = \frac{wL^4}{8EI}$

and $y_2 = -\frac{RL^3}{3EI}$

$\therefore$ $\Sigma y = \frac{wL^4}{8EI} - \frac{RL^3}{3EI} = 0$

$\therefore$ $R = \frac{3}{8}wL.$

85. For a beam of diameter '*d*' carrying a concentrated load *W* in the centre, if the values of *l*, *d*, and *W* are doubled, then its critical speed will

(*a*) double (*b*) become four times

(*c*) get halved (*d*) get one-fourth

(*e*) remain same.

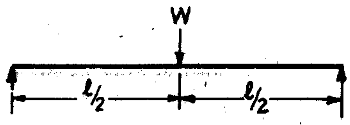


Fig. 43

Sol. (*e*) The critical speed $N \propto \frac{d^2}{l\sqrt{Wl}}$

N_N–new critical speed

$$\propto \frac{(2d)^2}{2l(\sqrt{2W \times 2l})}$$

$$\propto \frac{4d^2}{4l\sqrt{Wl}} \propto N$$

86. In the case of a beam supported at both ends, if the same load instead of being concentrated at centre is distributed uniformly throughout the length, then deflection in the centre will get reduced

(*a*) 1/2 time (*b*) 1/4 time

(*c*) 3/4 times (*d*) 3/8 times

(*e*) 5/8 times.

Sol. (*e*) Deflection in case of concentrated load

$$\delta_1 = \frac{Wl^3}{48EI}$$

Deflection in case of distributed load

$$\delta_2 = \frac{5}{384}\frac{Wl^3}{EI}$$

$$\therefore \quad \frac{\delta_2}{\delta_1} = \frac{5}{384}\frac{Wl^3}{EI} \times \frac{48EI}{Wl^3} = \frac{5}{8}$$

87. The flexural stress induced in an I section beam will be as shown in Fig. 44

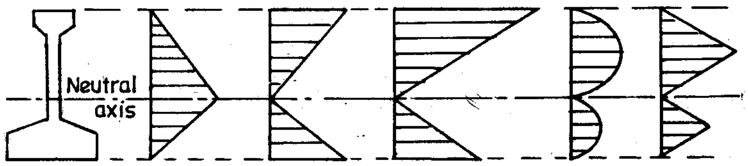


Fig. 44

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) *E*.

Sol. (*c*) The flexural stress is zero at neutral axis and for other fibres, it is linearly proportional to distance from the neutral axis. Thus curve *C* is applicable.

88. In a cantilever beam fixed at one end and free at other end, if the same load is distributed throughout instead of being concentrated at the end, then deflection at free end will reduce

(*a*) 1/2 time (*b*) 2/3 times
(*c*) 3/8 times (*d*) 5/8 times
(*e*) 3/4 times.

Sol. (*c*) In case of concentrated load, deflection$_1$

$$= \frac{Wl^3}{3EI}$$

and in case of distributed load deflection$_2$

$$= \frac{Wl^3}{8EI}$$

$$\therefore \quad \frac{\text{Deflection}_2}{\text{Deflection}_1} = \frac{Wl^3}{8EI} \times \frac{3EI}{Wl^3} = \frac{3}{8}$$

89. Two beams were placed one upon another whereas it was planned to place them side by side. The parameters of one beam are

Area (*A*) = 50 sq. cm depth (*d*) = 20 cm
Moment of Inertia (*I*) = 4000 cm^4, Section modulus (*S*) = 400 cm^2

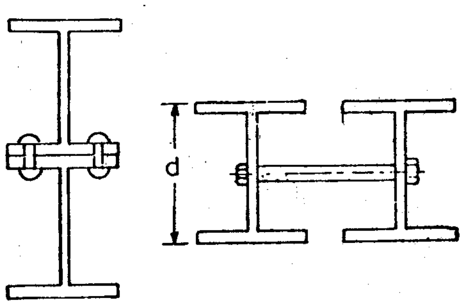


Fig. 45

The ratio of flexural stresses and deflections in these two cases (*i.e.* horizontal *vs.* vertical arrangement) will be

(*a*) 1, 2
(*b*) 2, 4
(*c*) 2.5, 4.5
(*d*) 1.5, 3
(*e*) 1.125, 2.25.

Sol. (*e*) For horizontal arrangement

$$I_h = 2I = 8000 \text{ cm}^4,$$
$$S_h = 2S = 800 \text{ cm}^3,$$

In vertical case

$$I_v = 2(I + AK^2) = 2(4000 + 50 \times 10^2)$$
$$= 2(4000 + 5000) = 18000 \text{ cm}^4$$
$$S_v = \frac{I_v}{d} = \frac{18000}{20} = 900 \text{ cm}^3$$

Flexural stresses are inversely proportional to section modulus

$$\therefore \quad \frac{f_h}{f_v} = \frac{S_v}{S_h} = \frac{900}{800} = 1.125$$

Deflection is inversely proportional to the moment of inertia,

$$\therefore \quad \frac{y_h}{y_v} = \frac{I_v}{I_h} = \frac{18000}{8000} = 2.25$$

90. In the study of deflection of beams, some quantities form a concatenation, *i.e.* each quantity in the series represents the gradient of the succeeding one. These quantities in order are :

(*a*) $w, M/EI, V, \theta, y$
(*b*) $w, y, V, \theta, M/EI$
(*c*) $y, M/EI, V, \theta, w$
(*d*) $w, V, M/EI, \theta, y$
(*e*) $M/EI, w, V, \theta, y$.

(w = load intensity, V = vertical shear, M = bending moment, y = deflection, θ = slope)

Sol. (*d*) Various relationships are

$$w = -\frac{dV}{dx}$$
$$V = \frac{dM}{dx}$$
$$\frac{M}{EI} = -\frac{d\theta}{dx}$$
$$\theta = \frac{dy}{dx}$$

Thus $w, V, M/EI, \theta$ and y form a concatenation.

91. If the total uniformly distributed load on a square flat plate supported at top and bottom of all four edges is doubled and the size of square plate (length and thickness) also doubled, then its central deflection will

(*a*) increase twice
(*b*) get halved
(*c*) increase four times
(*d*) get one-fourth
(*e*) remain same.

Sol. (*e*) For a square flat plate supported at top and bottom of all four edges and carrying a uniformly distributed load over the surface of the plate,

$$\text{deflection } \delta \propto \frac{Wl^2}{Et^3}$$

New deflection

$$\propto \frac{2W \times (2l)^2}{E \times (2t)^3} \propto \frac{8Wl^2}{8Et^3} \propto \delta$$

92. If in a cantilever beam of length l, the concentrated load P at end is replaced by a bending moment of $P \times l$, then deflection will increase by

(a) 1 time
(b) 1.25 times
(c) 1.5 times
(d) 2 times
(e) 2.5 times.

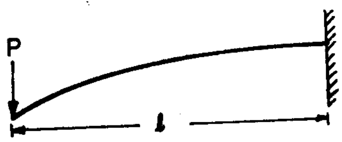


Fig. 46

Sol. (c) δ_{max} with concentrated load $= \dfrac{Pl^3}{3EI}$

and δ_{max} with moment of M

$$= \frac{Ml^2}{2EI} = \frac{Pl^3}{2EI}$$

$$\therefore \quad \text{ratio} = \frac{Pl^3}{2EI} \times \frac{3EI}{Pl^3} = \frac{3}{2} = 1.5.$$

93. The maximum deflection in case of loading for Fig. 47 will be

(a) $\dfrac{Wl^3}{192EI}$
(b) $\dfrac{Wl^3}{384EI}$
(c) $\dfrac{5}{384}\dfrac{Wl^3}{EI}$
(d) $\dfrac{3}{384}\dfrac{Wl^3}{EI}$
(e) $\dfrac{9}{384}\dfrac{Wl^3}{EI}$.

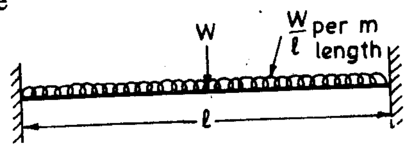


Fig. 47

Sol. (d) The problem can be solved by superposition method.

For a firmly supported beam at both ends, deflection with concentrated load W at centre

$$= \frac{Wl^3}{192EI}$$

and deflection with uniformly distributed load

$$= \frac{Wl^3}{384EI}$$

$\therefore$ deflection with both together $= \dfrac{Wl^3}{384EI}(2+1)$

$$= \frac{3Wl^3}{484EI}.$$

94. A beam with a rectangular section of 120 mm × 40 mm is placed horizontally by mistake, whereas it was designed to be placed vertically. The reduction in load carrying capacity will be

(a) 1/2
(b) 1/3
(c) 1/4
(d) 1/6
(e) 1/12.

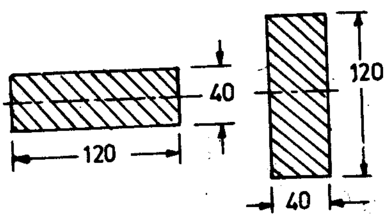


Fig. 48

Sol. (b) The load carrying capacity of beam is proportional to its section modulii.

In first case $\quad Z_h = \dfrac{bh^2}{6} = \dfrac{120 \times 40^2}{6}$

and in second case $\quad Z_v = \dfrac{40 \times 120^2}{6}$

$\therefore$ Ratio of $\quad \dfrac{Z_h}{Z_v} = \dfrac{120 \times 40 \times 40 \times 6}{6 \times 40 \times 120 \times 120} = \dfrac{1}{3}.$

95. The longitudinal shearing stress induced in the beam shown in Fig. 49 is equal to

(a) 15 kg/cm^2
(b) 30 kg/cm^2
(c) 40 kg/cm^2
(d) 45 kg/cm^2
(e) 60 kg/cm^2.

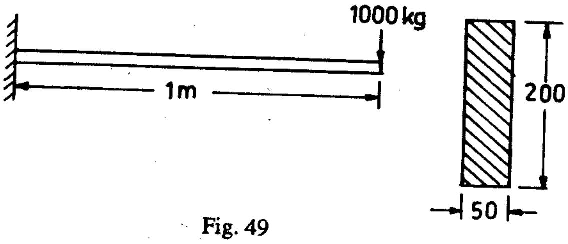


Fig. 49

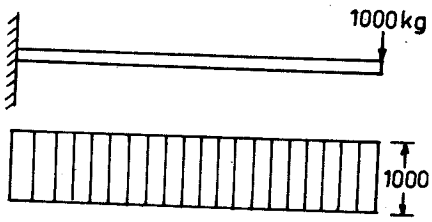


Fig. 50

Sol. (a) Vertical shear V is constant in case of cantilever beam.

$\therefore$ $$V = 1000 \text{ kg}$$

and longitudinal shearing stress

$$= \frac{3}{2}\frac{V}{A}$$

$$= \frac{3}{2} \times \frac{1000}{5 \times 20} = 15 \text{ kg/cm}^2.$$

96. The ratio of longitudinal shearing stress induced in two beams of rectangular and circular cross-section beams of same cross-sectional area for given constant vertical shear load will be

(a) 1
(b) 1.5
(c) 2
(d) 2.5
(e) 3.

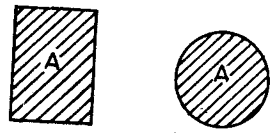


Fig. 51

Sol. (c) For rectangular section $$\tau_{max} = \frac{3V}{2A}$$

and for circular section $$T_{max} = \frac{4V}{3A}$$

$\therefore$ $$\text{Ratio} = \frac{3}{2} \times \frac{4}{3} = 2.$$

97. Fig. 52 shows the wing of a jet-liner of total weight W. It can be assumed to be a cantilever beam as shown. If M.I. be assumed to be constant ($= I$), then deflection of end A relative to cabin is equal to

(a) $\frac{11}{432}\frac{Wl^3}{EI}$
(b) $\frac{1}{48}\frac{Wl^3}{EI}$
(c) $\frac{5}{384}\frac{Wl^2}{EI}$
(d) $\frac{9}{378}\frac{Wl^2}{E^2I^2}$
(e) $\frac{12}{931}\frac{Wl^4}{EI}$

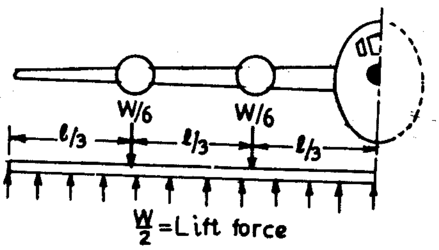
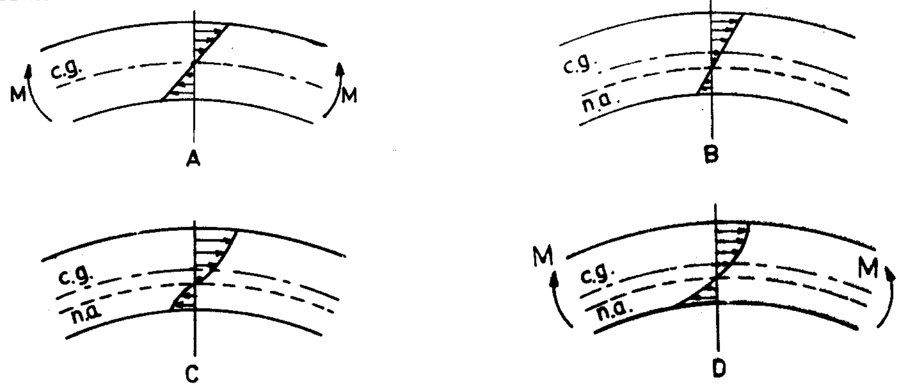


Fig. 52

Sol. (a) It must be remembered that deflection for a combination of loads on cantilever $\propto \frac{Wl^3}{EI}$. Thus answers at c, d and e are ruled out. Deflection of $\frac{1}{48}\frac{Wl^3}{EI}$ is applicable for a central load in the midspan of a simply supported beam and thus not possible in this case. The only alternative left is (a).

98. Fig. 53 shows the distribution of bending stress in curved beam. The correct distribution is shown in the following part of Fig. 53.

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) none of the above.



c.g. — center of gravity, n.a — neutral axis)

Fig. 53

Sol. (*d*) In curved beams, the neutral axis of the cross-section is shifted towards the centre of curvature of the beam, causing a non-linear distribution of stress. The magnitude of stresses is more on inner fibres and less on outer fibres as shown in part *D* of Figure 53.

99. The vertical deflection δ of a semicircular ring of radius R when its radius is doubled will be ________ times compared to earlier value

(*a*) 2 (*b*) 4
(*c*) 8 (*d*) 16
(*e*) 32.

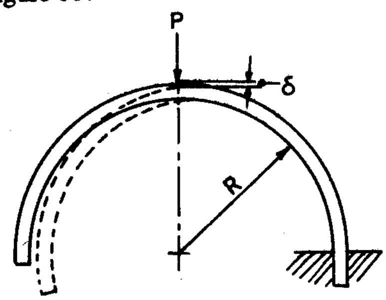


Fig. 54

Sol. (*c*) The vertical deflection of a semi-circular ring

$$\delta = \frac{\pi P R^3}{4EI}$$

Thus when R is doubled,

δ will be 8 times the previous value.

100. An aluminium alloy has a modulus of elasticity of 64×10^4 kg/cm^2 and a yield strength of 400 kg/cm^2. The least value of slenderness ratio will be around

(*a*) 75 (*b*) 90
(*c*) 100 (*d*) 110
(*e*) 125.

Sol. (*e*) The least value of slenderness ratio can be found from Euler's equation

$$s_{cr} = \frac{\pi^2 E}{(l/r)^2} \qquad (s_{cr} = \text{critical stress} = \text{yield point stress } s_{yp})$$

or

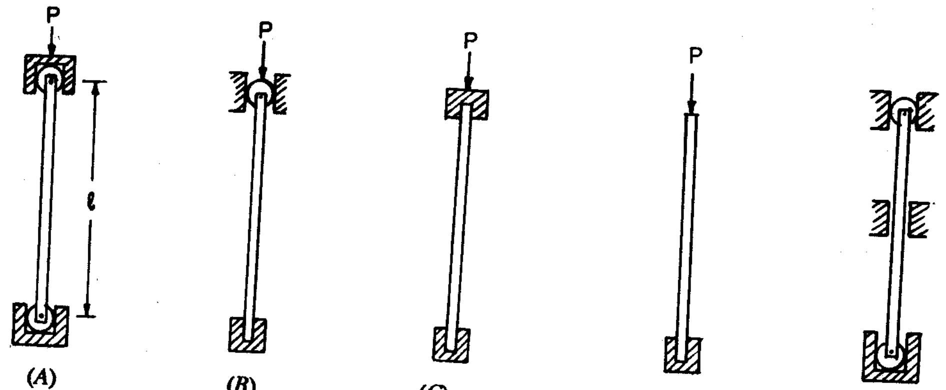
$$\frac{l}{r} = \sqrt{\frac{\pi^2 E}{s_{yp}}}$$

$$= \pi\sqrt{\frac{64 \times 10000}{400}}$$

$$= 40\pi \cong 125.$$

101. If l is the length of column when supported by hinged ends as shown in Fig. 55 (*a*), then the equivalent lengths for cases *B*, *C*, *D* and *E* respectively will be

(*a*) 0.7*l*, 0.5*l*, 2*l*, 1.5*l*
(*b*) 0.7*l*, 2*l*, 0.5*l*, 2*l*
(*c*) 0.5*l*, 0.7*l*, 1.5*l*, 0.3*l*
(*d*) 0.5*l*, 2*l*, 1.5*l*, 0.7*l*
(*e*) 0.7*l*, 0.5*l*, 2*l*, 0.5*l*.



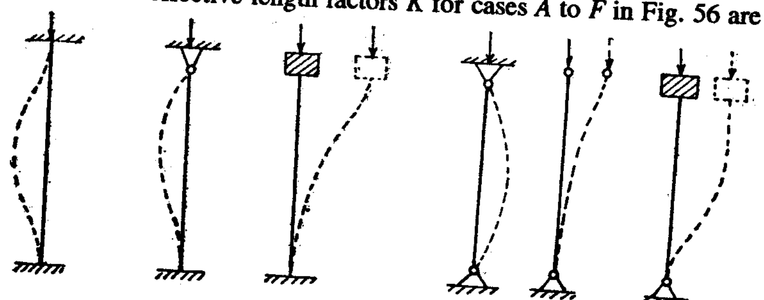
(*A*) (*B*) (*C*) (*D*) (*E*)

Fig. 55

Sol. (*e*) The critical length for (*B*), *i.e.*, one end hinged and other end fixed is 0.7*l* ; for case (*C*), *i.e.* both ends fixed, the critical length is 0.5*l*.

For case (*D*), *i.e.*, one end fixed and other free, the critical length is 2*l*. For case (*E*) *i.e.* both ends hinged and middle braced, is, in effect, equal to two columns, one on top of the other, and to fail by buckling, each half must collapse. The effective length therefore is *l*/2 or 0.5*l*.

102. The theoretical values of effective length factors *K* for cases *A* to *F* in Fig. 56 are



(*A*) (*B*) (*C*) (*D*) (*E*) (*F*)

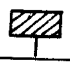
Condition	Rotation	Translation
	Fixed	Fixed
	Free	Fixed
	Fixed	Free
	Free	Free

Fig. 56

(*a*) 0.5, 0.7, 1.0, 1.0, 2.0, 2.0
(*b*) 0.5, 1.0, 0.7, 1.0, 2.0, 2.0

(*c*) 0.7, 0.5, 1.0, 2.0, 1.0, 2.0 (*d*) 2.0, 0.7, 1.0, 1.0, 0,5, 0,5
(*e*) 1.0, 1.0, 0.7, 0.7, 0.5, 2.0.

Sol. (*a*) The correct answer is at (*a*).

103. The ratio of critical loads a column can carry when its end conditions are best and worst is
(*a*) 2 (*b*) 4
(*c*) 8 (*d*) 16
(*e*) 32.

Sol. (*d*) The best condition for a column is when its both ends are fixed and value of n in Euler's formula

$$F_{crit} = \frac{n\pi^2 EI}{l^2} \text{ is } 4$$

The worst condition is when one end of column is fixed and other end is free. The value of n in such a case is $\frac{1}{4}$.

$\therefore$ Ratio of best to worst case is $4 \div \frac{1}{4} = 16$.

104. Fig. 57 shows an eccentrically loaded strut (beam column). If K = radius of gyration and A = cross-sectional area, E = modulus of elasticity then the moment introduced =

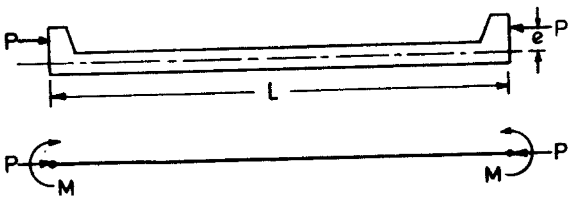


Fig. 57

(*a*) $P_e \sec \frac{L}{2K} \sqrt{\frac{P}{EA}}$ (*b*) $P_e \operatorname{cosec} \sqrt{\frac{P}{EA}}$
(*c*) $P_e \tan \frac{L}{2K} \sqrt{\frac{P}{EA}}$ (*d*) $P_e \sin \frac{P}{2K} \sqrt{\frac{P}{EA}}$
(*e*) $P_e \cos \frac{L}{2K} \sqrt{\frac{P}{EA}}$.

Sol. (*a*) The correct relationship is $M = P_e \sec \frac{L}{2K} \sqrt{\frac{P}{EA}}$

105. A freely supported column at both ends is braced at two points at equidistance as shown in Fig. 58. This column in comparison to unbraced column will be following times stronger
(*a*) 3
(*b*) 6
(*c*) 9
(*d*) 18
(*e*) 27.

Sol. (*c*) The braced column is in effect, 3 columns, one on top of the other. To fail by buckling each one-third must collapse. The effective length of new column is $l/3$, thereby making the column 9 times stronger than when unbraced; thus

$$P_{er} = \frac{\pi^2 EI}{(l/3)^2} = \frac{9\pi^2 EI}{l^2}.$$

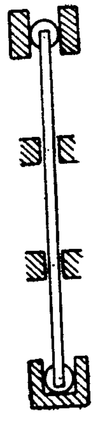
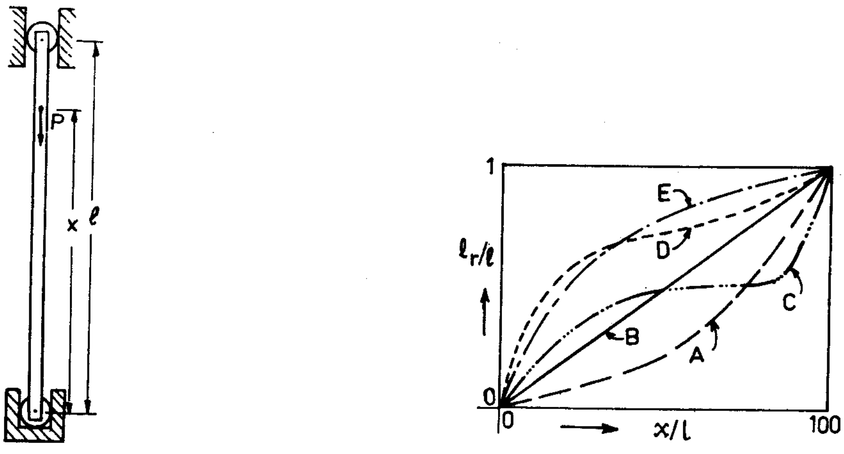


Fig. 58

106. Fig. 59 (*a*) shows a column hinged at both the ends. The load *P*, instead of being applied at top, is changed in position from top to downwards. The ratio of reduced length l_r to effective length l will vary as shown by curve in Fig. 59 (*b*).



(*a*) (*b*)

Fig. 59

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) *E*.

Sol. (*d*) Fig. 60 shows the more exact curve for reduced length ratio for variation in load position ratio. Thus correct relationship is shown by curve *D*.

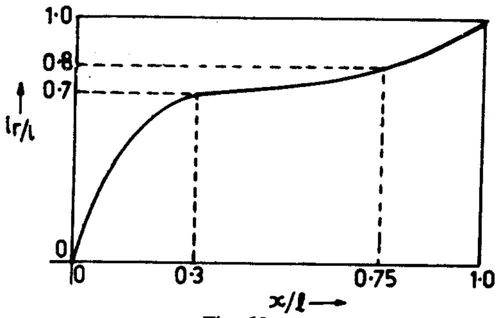
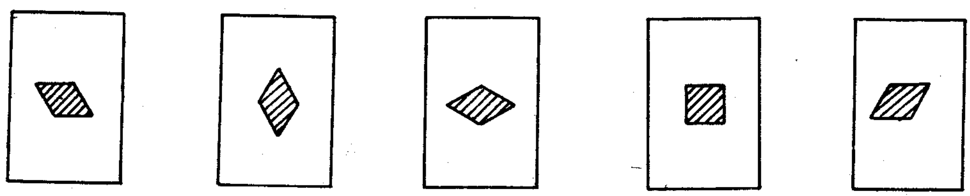


Fig. 60

107. The kern is the area around the centre of gravity of a cross-section within which any load applied will produce stress of only one sign throughout the entire cross-section. Outside the kern, a load produces stresses of different sign. For a circle of diameter, '*d*', kern lies in a diameter of $d/4$. For a rectangular section it is rhombus as shown in following part of Fig. 61.



(*A*) (*B*) (*C*) (*D*) (*E*)

Fig. 61

(*a*) A (*b*) B
(*c*) C (*d*) D
(*e*) E.

Sol. (*b*) The correct answer is (*b*) and the dimensions of kern are as shown in Fig. 62.

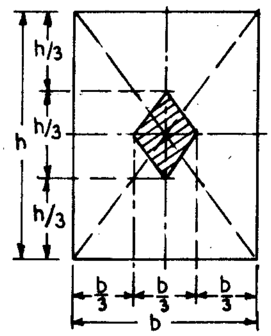
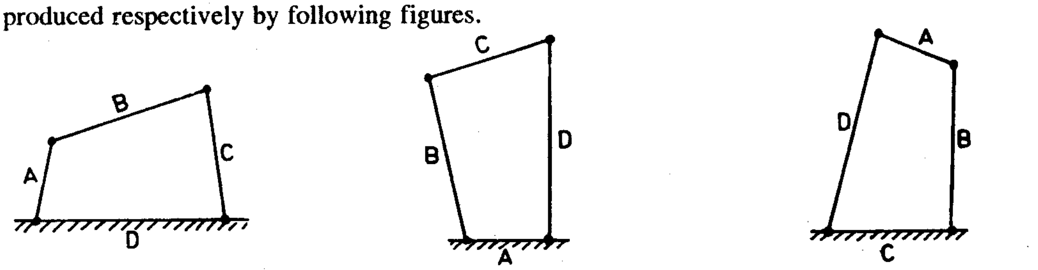


Fig. 62

108. Pick up the false statement about kern
(*a*) Compressive forces acting within the kern of a section can't produce tensile stresses
(*b*) The stress at the boundary of the kern is zero
(*c*) In a circle, the kern is circle, in a square, the kern is a square, and in a rectangle, the kern is rectangle
(*d*) The kern of a circular section of diameter D is a concentric circular area having a diameter of $D/4$
(*e*) The kern of a square section is a concentric square of 1/9 the area of the original area.

Sol. (*c*) All statements are true, except the last part of (*c*). The kern of a rectangular section is a rhombus.

109. Fig. 63 shows three alternatives with four link chain mechanism, by fixing link *D*, *A* and *C* respectively. The Drag link mechanism used to feather the floats on paddle wheels; beam-and-crank mechanism used on side-wheel steamers; and rocker mechanism used in straight-line motion is produced respectively by following figures.



(1) A rorates and C oscillates (2) Links B and D rotate (3) Links D and B oscillate
Fig. 63

(*a*) 1, 2, 3 (*b*) 2, 1, 3
(*c*) 3, 2, 1 (*d*) 3, 1, 2
(*e*) 2, 3, 1.

Sol. (*b*) Fig. 62 (1) gives beam-and -crank mechanism.
Fig. 62 (2) gives drag link mechanism.
Fig. 62 (3) gives rocker mechanism.

110. For the torsional pendulum shown in Fig. 64, if the values of *d*, *l*, *r* and *M* be doubled, then the time of one complete oscillation will
(*a*) double (*b*) become four times
(*c*) get halved (*d*) get one-fourth
(*e*) remain same.

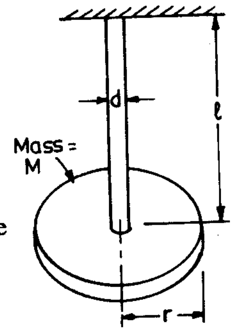


Fig. 64

Sol. (*e*) The formula for time of one complete oscillation

$$T = 8\sqrt{\frac{\pi M r^2 l}{d^4 G}}$$

For New case

$$T_r = 8\sqrt{\frac{\pi \times 2M \times (2r)^2 \times 2l}{(2d)^4\, G}}$$

$$= 8\sqrt{\frac{16\pi M r^2 l}{16 d^4\, G}} = T.$$

111. In a flywheel, it is desired to reduce the speed to half but to keep the speed variation constant and also the mass of flywheel same. This is possible if the mean diameter of flywheel is

(*a*) reduced to half
(*b*) increased twice
(*c*) increased four times
(*d*) increased $\sqrt{2}$ times
(*e*) kept same.

Sol. (*b*) Weight of flywheel $\propto \frac{nE}{D^2 N^2}$

(n = variation of speed,
E = total energy required per stroke,
D = mean diameter, N = RPM)

∴ $$W = \frac{nE}{D^2 N^2} = \frac{nE}{(D')^2 (\frac{1}{2}N)^2} = \frac{nE}{(2D)^2 \left(\frac{1}{2}N\right)^2}$$

∴ New diameter should be $2D$.

112. The working depth of an involute gear is equal to

(*a*) addendum
(*b*) dedendum
(*c*) addendum + dedendum
(*d*) 2 × addendum
(*e*) 2 × dedendum.

Sol. (*d*) Working depth is twice of addendum and whole depth is sum of addendum and dedendum.

113. Tooth thickness on pitch line of involute gear in terms of module (m) is equal to

(*a*) 1.157 m
(*b*) 1.167 m
(*c*) 2 m
(*d*) 1.5708 m
(*e*) 2.157 m.

Sol. (*d*) Tooth Thickness = 1.5708 × module.

114. The outside diameter of an involute gear is equal to pitch circle diameter plus

(*a*) 2 addendum
(*b*) 2 dedendum
(*c*) addendum + dedendum
(*d*) 3.1416 module
(*e*) 2.157 module.

Sol. (*a*) Addendum is the portion of gear tooth above the pitch circle diameter (*PCD*). Therefore outside diameter of involute gear = *PCD* + 2 addendum.

115. Pick out the false statement about relationships of spur-gears.

(*a*) Pitch diameter = module × No. of teeth
(*b*) Module $= \frac{25.4}{\text{diametral pitch}}$
(*c*) dedendum = 1.25 × module
(*d*) Base pitch = module × π × sin ϕ (ϕ = pressure angle)
(*e*) Base circle diameter = pitch diameter × cos ϕ.

Sol. (*d*) The false statement is

Base pitch = module × π × sin ϕ

In fact, correct relationship of base pitch = module × π × cos ϕ.

116. Which of the following is not the correct property of involute curve ?

(*a*) The form or shape of an involute curve depends upon the diameter of the base circle from which it is derived
(*b*) The angular motion of two involute gear teeth rotating at a uniform rate will be uniform, irrespective of the centre distance
(*c*) The relative rate of motion between driving and driven gears having involute tooth curves, is established by the diameters of their pitch circles
(*d*) The pitch diameters of mating involute gears are directly proportional to the diameters of their respective base circles
(*e*) The true pitch circle diameters of involute gears are affected by a change in the centre distance.

Sol. (*c*) All statements except at (*c*) are correct. The correct statement for (*c*) is – The relative rate of motion between driving and driven gears having involute tooth curves, is established by the diameters of their base circles (and not pitch circles).

117. Which of the following gear ratio does not result in hunting tool
(*a*) 77/20 (*b*) 76/21
(*c*) 75/22 (*d*) 73/24
(*e*) 71/25.

Sol. (*e*) When several pairs of gears operating at the same centre distance are required to have hunting ratios, this can be accomplished by having the sum of the teeth in each pair equal to a prime number. For *a, b, c,* and *d,* it would be seen that sum of teeth in these cases is 97 which is a prime number but for *e*, the sum is 96, which does not result in hunting tooth.

118. In measuring the chordal thickness, the vertical scale of a gear tooth caliper is set to the chordal or corrected addendum to locate the caliper jaws at the pitch line. If a = addendum, t = circular thickness of tooth at pitch diameter D, then chordal thickness is equal to
(*a*) $a+\frac{t}{D}$ (*b*) $a+\frac{t^2}{D}$
(*c*) $a+\frac{t^2}{2D}$ (*d*) $a+\frac{t^2}{4D}$
(*e*) $a+\frac{t^3}{6D}$.

Sol. (*d*) The correct relationship is chordal thickness

$$=a+\frac{t^2}{4D}.$$

119. Tick the odd item out
(*a*) gear (*b*) lever
(*c*) differential pulley (*d*) shafting
(*e*) screw.

Sol. (*d*) All items except shafting are mechanical transformers, *i.e.* either multiply force or motion.

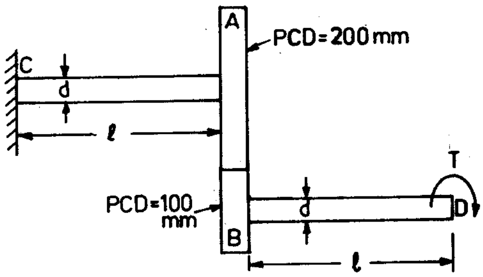


Fig. 65

120. A torque T is applied at D at the end of a shaft connected through gears B and A to another shaft fixed at C. The angle of twist at D in this case in comparison to when end B is fixed and not engaged with gear A, will be

(*a*) 5 times (*b*) 4 times
(*c*) 3 times (*d*) 2 times
(*e*) same.

Sol. (*a*) The torque acting in shaft

$$CA = 2 \times \text{torque in shaft } BD$$

This is because the contact force is same between two gears and *PCD* of gear *B*.

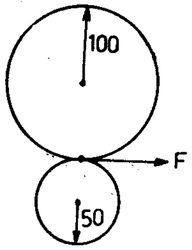


Fig. 66

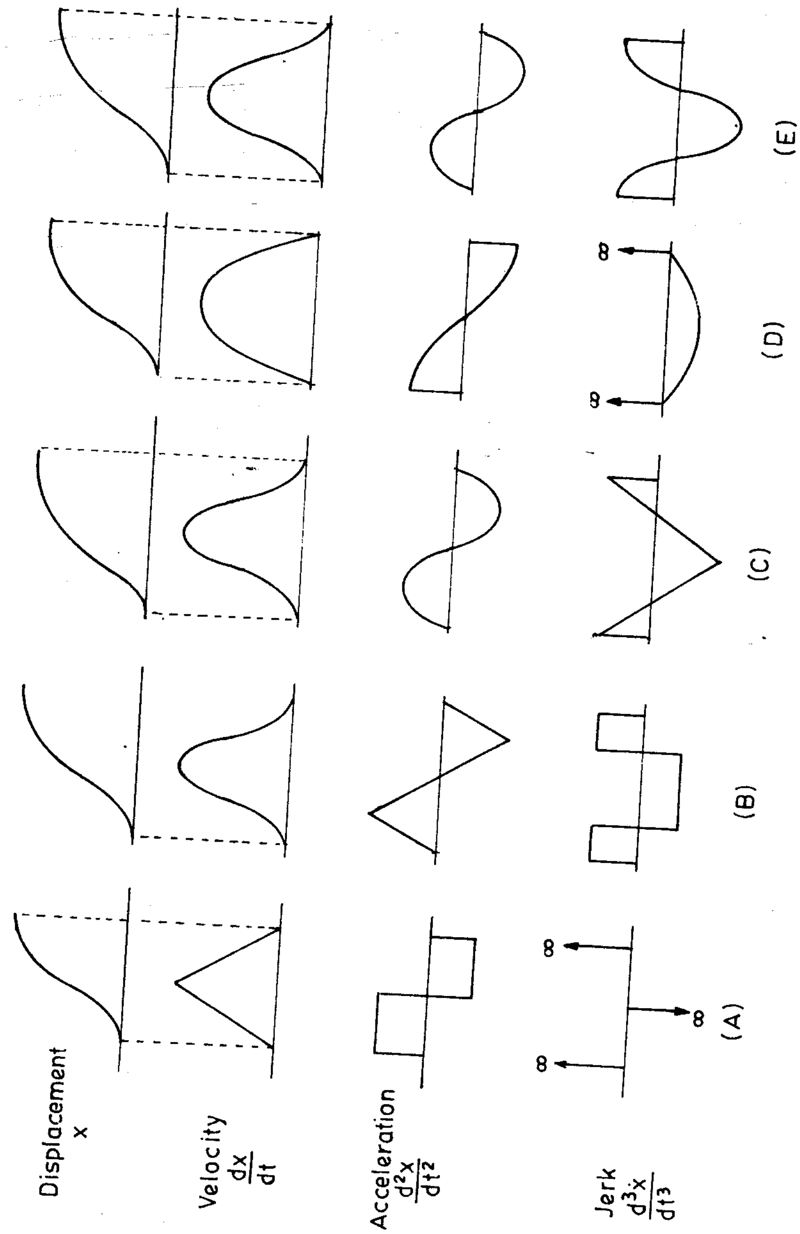


Fig. 67

Also a study of the geometry of motion indicates that angle of rotation of gear B is twice the rotation of gear A

i.e. $$\theta_B = 2\theta_A$$

Total rotation at D = angle of twist of shaft $BD + 2 \times$ angle of twist of shaft CA.

$$= \frac{Tl}{G} \times \frac{32}{\pi d^4} + 2\left(\frac{2Tl}{G} \times \frac{32}{\pi d^4}\right)$$

$$= \frac{Tl}{G}\left(\frac{32}{\pi d^4}\right)(1+4) = 5 \times \text{angle of twist of } BD.$$

121. Arrange the following drives on the basis of first cost : Gears (G), roller chains (R), flat belts (F), V-belts (V), silent chains (S).
(*a*) *F, V, R, S, G* (*b*) *G, S, R, V, F*
(*c*) *F, R, V, S, G* (*d*) F, *G, V, R, S*
(*e*) *F, V, S, G, R.*

Sol. (*a*) In general the comparative first cost is in the order of flat belts, V-belts, roller chain, silent chain, and gears.

122. Fig. 68 shows the displacement, velocity, acceleration, and jerk diagrams for various cams. The curves applicable for simple harmonic, cycloidal, second power polynomial, third power polynomial, and fourth power polynomials respective are given by following parts of Fig. 67 (*page 731*)
(*a*) *D, E, A, B, C* (*b*) *E, D, A, B, C*
(*c*) *A, B, C, D, E* (*d*) *C, D, A, B, E*
(*e*) *A, B, C, E, D.*

Sol. (*a*) An analysis of x, dx/dt, d^2x/dt^2, and d^3x/dt^3 will clearly reveal that curves A, B, and C are for 2nd order, 3rd order and 4th order polynomial forms, D is for simple harmonic, and E is for cycloidal form.

123. Two springs are joined with no prestress to a lever as shown in Fig. 68. The reactions at supports A and B will be
(*a*) 200 kg, 100 kg (*b*) 100 kg, 200 kg
(*c*) 450 kg, 900 kg (*d*) 900 kg, 450 kg
(*e*) 200/3 kg, 100/3 kg.

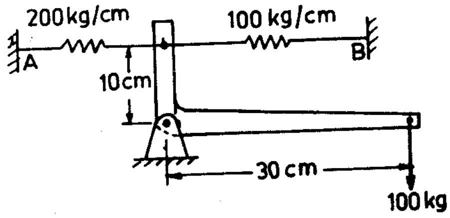


Fig. 68

Sol. (*a*) The load produced at the end of shorter lever $= 100 \times \frac{30}{10} = 300$ kg.

Since both the springs are constrained at both the ends and extension is same in both, they act as if connected in parallel. Therefore combined stiffness

$$= 200 + 100 = 300 \text{ kg/cm}.$$

$\therefore$ Extension by a load of 300 kg$= \frac{300}{300} = 1$ cm

Thus reaction at $A = 200 \frac{\text{kg}}{\text{cm}} \times 1 \text{ cm} = 200$ kg and at $B = 100 \times 1 = 100$ kg.

124. A sign board weighing 200 kg is supported by a horizontal bar and inclined cable at 45° as shown in Fig. 69. Neglecting the weight of bar, the tension in cable is

(*a*) $112.5\sqrt{2}$ kg
(*b*) $225\sqrt{2}$ kg
(*c*) $112.5\sqrt{3}$ kg
(*d*) $200/\sqrt{2}$ kg
(*e*) $200\sqrt{2}$ kg.

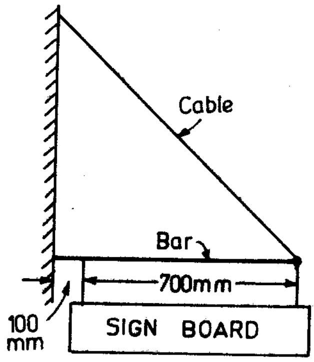


Fig. 69

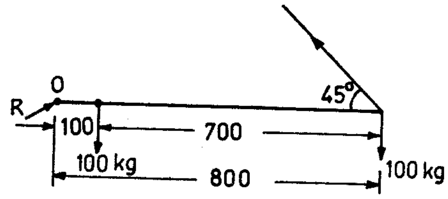


Fig. 70

Sol. (*a*) Fig. 70 shows the free-body diagram of the bar. Let T be the tension in cable. Then lever arm of tension T w.r.t. O is

$$800 \sin 45° = \frac{800 \times \sqrt{2}}{2}$$
$$= 400\sqrt{2}$$
$$\Sigma M_0 = 100 \times 100 + 100 \times 800 - T \times 400\sqrt{2} = 0$$

or
$$T = \frac{900 \times 100}{400\sqrt{2}}$$
$$= \frac{900}{4\sqrt{2}} = 112.5\sqrt{2} \text{ kg.}$$

125. Given below are some definitions in connection with pipe fittings. Match them properly

A	*B*
I. A device used to connect pipes	1. nipple
II. A tubular pipe fitting usually threaded on both ends and under 300 mm in length	2. manifold
III. A threaded sleave used to connect two pipes	3. coupling
IV. A fitting with numerous branches used to convey fluids between a large pipe and several smaller pipes	4. elbow
V. A fitting that makes an angle between adjacent pipes.	5. union

The correct sequence for I to V is

(*a*) 5, 1, 3, 2, 4
(*b*) 1, 5, 3, 4, 2
(*c*) 3, 1, 5, 2, 4
(*d*) 5, 1, 2, 3, 4
(*e*) 2, 4, 5, 1, 3.

Sol. (*a*) The correct answer is

I-5, II-1, III-3, IV-2, V-4.

126. Fig. 71 shows four cross-sections of a bar to be heat treated. Arrange them in the order of ideally suited section to worst one as regards convenience in heat treating them

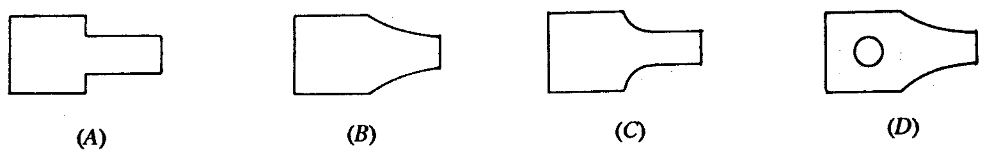


Fig. 71

(*a*) *B, C, D, A* (*b*) *C, B, D, A*
(*c*) *D, C, B, A* (*d*) *D, B, C, A*
(*e*) *B, C, A, D.*

Sol. (*a*) Internal stresses set up during heat treatment pose lot of problems of cracks etc. Cracks can develop at re-entraint corners because of unequal cooling of the wide and narrow portions. The worst case is *A*.

An improvement results by introducing fillets as at *C*. It is therefore better choice. Still better results are achieved by having gradual transition slopes as at *B*. It is therefore next better choice. Choice *D* is best because it tries to equalise mass of thicker and thinner portions.

127. A circular specimen shown in Fig. 72 is to be loaded in
(*A*) tension (*B*) direct shear
(*C*) bending (*D*) torsional shear

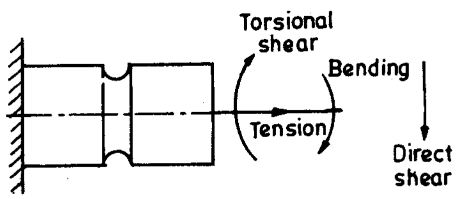


Fig. 72

Arrange these loadings in descending order as regards severity of stress concentration factor.
(*a*) *A, B, C, D* (*b*) *A, C, B, D*
(*c*) *B, A, C, D* (*d*) *D, A, B, C*
(*e*) *C, B, A, D.*

Sol. (*b*) As per the stress concentration factor curves, the correct decreasing order of stress concentration factor for this kind of situation is

Tension, Beding, Direct shear, Torsional shear.

128. Fig. 73 shows three specimens with different notches. These specimens are loaded in tension and bending. Pick up correct statement whether *A, B, C* are stronger in bending or tension

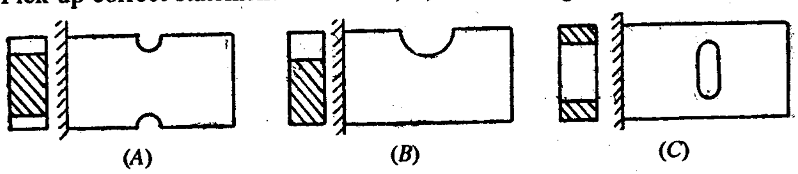


Fig. 73

(*a*) *A*—strong in bending. *B*—strong in tension, *C*—equally strong in bending and tension
(*b*) *A*—strong in tension, *B*—strong in bending, *C*—equally strong in bending and tension
(*c*) *A*—equally strong in tension and bending, *B*—strong in tension, *C*—strong in bending
(*d*) All are equally strong in both bending and tension.
(*e*) *A* and *B* are equally strong in bending and tension, and *C* is stronger in bending.

Sol. (*a*) As per stress concentration factor diagrams, *A* is stronger in bending (high stress concentration factor in tension than in bending), *B* is stronger in tension, and *C* is equally strong in both bending and tension.

129. Large cylindrical tanks sealed in warm weather are found to buckle and collapse when temperature drops a few degrees. This can be avoided by

(*a*) using thick sheets with adequate safety margin
(*b*) providing ribs inside (*c*) keeping inside pressurised
(*d*) keeping inside under vacuum (*e*) providing a vent on the tank.

Sol. (*e*) A drop in temperature causes a drop in internal pressure and thus greater pressure acts on the walls of the vessel which are placed in compression with the resultant buckling. The most economical and easier way to overcome the problem is to vent the vessel so that pressure cannot fall.

130. The major axis of elliptical manholes should be

(*a*) circumferential on a shell (*b*) longitudinal on a shell
(*c*) at 45° to circumferential
(*d*) the exact orientation depending on the diameter and pressure of shell
(*e*) none of the above is true.

Sol. (*a*) The least amount of unit strain is experienced when the long axis is circumferential. There is twice the amount of unit stress on a longitudinal seam in comparison to that on a girth seam.

131. Identify the machine screw heads given in Fig. 74.

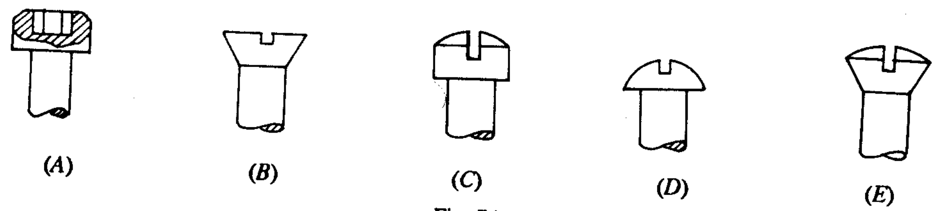


Fig. 74

Socket head, oval head, fillister head, flat head, round head respectively are indicated at

(*a*) *A, C, D, B, E* (*b*) *B, C, E, A, D*
(*c*) *A, D, C, B, E* (*d*) *A, E, D, B, C*
(*e*) *C, B, D, A, E.*

Sol. (*d*) Socket head has opening for inserting key and is shown at *A*.

Oval head has rounded top the tapered head and is shown at *E*.

Fillister head has rounded top and flat base below the head and is shown at *D*.

Flat head is flat at top and has tapered head as at *B*.

Round head is with cylindrical top rounded at top as at *C*.

132. A log of diameter '*d*' is available. It is proposed to cut out a strongest beam from it. The size *b* should be equal to

(*a*) $d/2$ (*b*) $d/\sqrt{2}$
(*c*) $2d/3$ (*d*) $3d/4$
(*e*) $d/\sqrt{3}$.

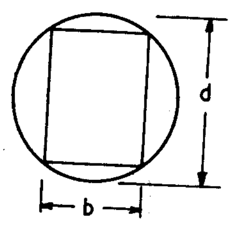


Fig.75

Sol. (*e*) To solve above problem, we must find a value of *b* that will give a maximum section modulus

$$Z = \frac{b(d^2 - b^2)}{6}$$

or $$\frac{dZ}{db} = d^2 - 3b^2 = 0$$

and $$b^2 = \frac{d^2}{3}$$

$$b = \frac{d}{\sqrt{3}}.$$

133. If the moment on a beam is increased three times, then to keep the stress in the beam same, the sectional modulus should be

(*a*) increased 3 times (*b*) decreased 3 times
(*c*) increased 1.5 times (*d*) increased 9 times
(*e*) increased 6 times.

Sol. (*a*) Stress in beam $= \frac{M}{Z}$

If M is made three times, Z, should also be made 3 times for same value of stress.

134. Fig. 76 shows the various cross-sections of steel beams. If their length and the product of their cross-sectional area and their depth are same for all these, then arrange them in descending order for their load capability in the middle.

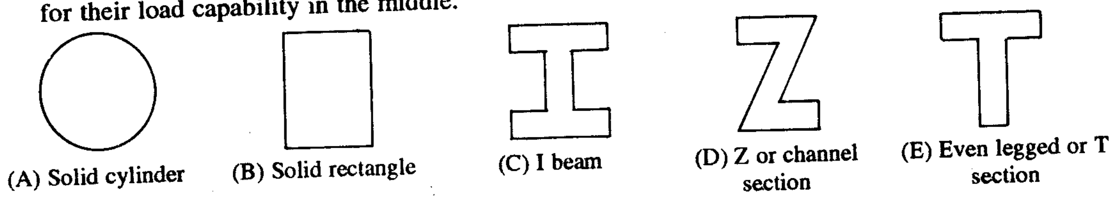


Fig. 76

(*a*) *C, D, B, E, A* (*b*) *C, B, D, A, E*
(*c*) *D, B, C, E, A* (*d*) *A, E, B, D, C*
(*e*) *B, E, D, C, A*.

Sol. (*a*) The correct answer is (*a*) because the maximum load that can be carried at centre by these beams are approximately in the ratio of

1795 : 1525 : 890, 885, 667 respectively.

135. Fig. 77 shows how the efficiency of screw varies with change in the lead angle of screw thread. The correct curve applicable is

(*a*) *A* (*b*) *B*
(*c*) *C* (*d*) *D*
(*e*) *E*.

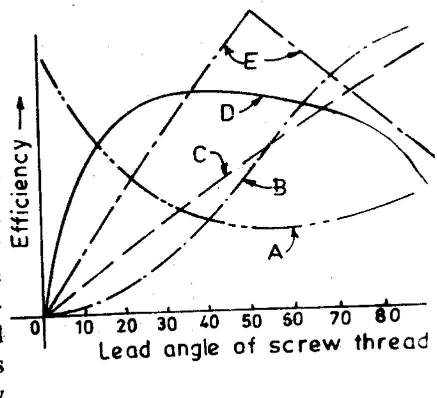


Fig. 77

Sol. (*d*) The efficiency of a lead screw with increase in lead angle increases first, reaches nearly maximum value around 45° and starts dropping thereafter. The work of thread friction is equal to the frictional force along the thread multiplied by the distance through which this force acts. For lower value of lead angle, the slope of the thread is small, and the distance through which the friction force acts is great compared with lead of the thread. Therefore work of thread friction is great as compared with the useful work, and a low efficiency results. For large angle, normal thread force becomes large and likewise the force of friction and the work of friction become large as compared with the useful work.

At around 45°, value of friction is minimum compared with the useful work and hence efficiency is maximum.

136. For transmitting same power by a shaft, if its speed is doubled, the new diameter should be made

(*a*) half of earlier diameter
(*b*) $\sqrt{2}$ of earlier diameter
(*c*) $1/\sqrt{2}$ of earlier diameter
(*d*) $\sqrt[3]{\frac{1}{2}}$ of earlier diameter
(*e*) $\sqrt[4]{\frac{1}{2}}$ of earlier diameter.

Sol. (*d*) Power $\propto D^3N$

$\therefore$ $D^3N = (D_n)^3 \times 2N$ or $D_n = \sqrt[3]{\frac{1}{2}}D$.

137. If the torsional moment to be transmitted and the length of a shaft are doubled, then to keep same torsional deflection, the diameter of shaft should be increased

(*a*) 2 times
(*b*) 4 times
(*c*) $\sqrt{2}$ times
(*d*) $\sqrt[3]{2}$ times
(*e*) $\sqrt[4]{2}$ times.

Sol. (*c*) The diameter of a shaft to have a maximum torsional deflection α is given by

$$D = 4.9\sqrt[4]{\frac{Tl}{G\alpha}}$$

where, (T = torsional moment in N-mm,
l = length in mm,
G = torsional modulus of elasticity in N/mm²)

Now $$D' = 4.9\sqrt[4]{\frac{2T \times 2l}{G\alpha}}$$

$\therefore$ $$\frac{D'}{D} = \frac{\sqrt[4]{4}}{1} = \sqrt{2}.$$

138. In a shaft for a particular application, the torsional deflection has to be limited to a specified value. If its torque transmitted is increased 4 times and the length of shaft also increased four times, then diameter of shaft should be increased

(*a*) 16 times
(*b*) 8 times
(*c*) 4 times
(*d*) 2 times
(*e*) $\sqrt{2}$ times.

Sol. (*d*) Diameter of a shaft $\propto \sqrt[4]{\frac{Tl}{G\alpha}}$

Since G–torsional modulus of rigidity and α—angle of twist are same

$$D \propto \sqrt[4]{Tl}$$

$\therefore$ New $$D \propto \sqrt[4]{4T \times 4l} \propto 2\sqrt{Tl}$$

$\therefore$ new diameter has to be twice the earlier diameter.

139. If a shaft is required to transmit twice the power at twice the speed for which it is designed, its diameter must

(*a*) increase 4 times
(*b*) increase 2 times
(*c*) increase $\sqrt{2}$ times
(*d*) decrease 2 times
(*e*) remain same.

Sol. (*e*) Diameter of a shaft $\propto \sqrt[4]{\frac{P}{N}}$

P = power to be transmitted
N = r.p.m.

Since P and N both are increased twice, the diameter remains unaffected.

140. If the torque to be transmitted by a shaft is doubled for same torsional deflection of shaft, its diameter should be made

(a) 2 times earlier
(b) $\sqrt{2}$ times earlier
(c) $\sqrt[3]{2}$ times earlier
(d) $\sqrt[4]{2}$ times earlier
(e) $2^{3/2}$ times earlier.

Sol. (d) Torsional deflection $\propto \dfrac{Tl}{D^4G}$

$$\therefore \quad \frac{T}{D^4} = \frac{2T}{(D')^4}$$

or $$D' = \sqrt[4]{2}D.$$

141. If the power to be transmitted by a shaft and its speed are both doubled, then for same torsional deflection of the shaft, its diameter should be

(a) halved
(b) doubled
(c) made four times
(d) made one-fourth
(e) kept same.

Sol. (e) $$D \propto \sqrt[4]{\frac{P}{N}} \quad \begin{pmatrix} P = \text{power} \\ N = \text{RPM} \end{pmatrix}$$

Since both P and N are doubled, D remains same.

142. Compare the strength of a solid shaft and a hollow shaft, both having outside diameter D. Hollow shaft has inside diameter $D/2$.

The strength of hollow shaft in comparison to solid shaft is

(a) half
(b) one-fourth
(c) seven-eighth
(d) three-fourth
(e) $\dfrac{15}{16}$ times.

Sol. (e) For solid shaft $$S_{s\,max} = \frac{16T}{\pi D^3}$$

and for hollow shaft $$S_{s\,max} = \frac{16TD}{\pi(D_0^4 - D_i^4)}$$

$$= \frac{16TD}{\pi D^4 (1 - (\frac{1}{2})^4)}$$

$$= \frac{16T}{\pi D^3}\left(\frac{1}{1 - \frac{1}{16}}\right)$$

$$= \frac{16T}{\pi D^3} \times \frac{16}{15}$$

Thus in hollow shaft maximum shear stress induced is 16/15 times that in solid shaft.

In other words hollow shaft is 15/16 times as strong as solid shaft.

143. The load carrying ability of a sliding bearing depends upon the kind of fluid film which is formed between its moving surfaces. The formation of this film is dependent on design of bearing and speed of rotation. The three modes or regions of operation in Fig. 78 are represented by A, B and C. These are

(a) full film, mixed, boundary
(b) mixed, full film, boundary
(c) boundary, full film, mixed
(d) full film, boundary, mixed
(e) boundary, mixed, full film.

Sol. (*e*) Full film, or hydrodynamic lubrication results in low friction and long wear-free service life (represented by *C*). Boundary lubrication takes place when the sliding surfaces are rubbing together with only an extremely thin film of lubricant present. These bearings are usually grease lubricated or periodically oil lubricated (Refer *A*).

Mixed-film lubrication is a mode of operation between the full film and boundary modes, (represented by *B*).

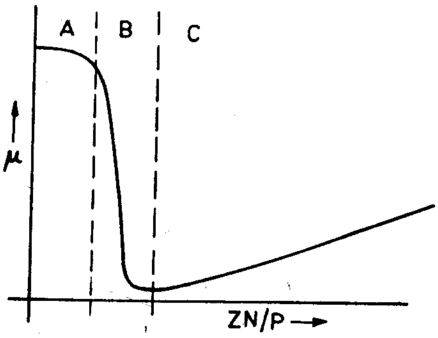


Fig. 78

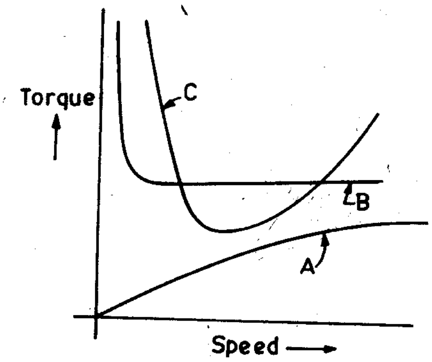


Fig. 79

144. Fig. 79 shows the torque/speed characteristics of rolling and fluid film bearings. The curves for rolling bearing, hydrostatic and hydrodynamic bearings are represented by curves

(*a*) *A, B, C* (*b*) *C, B, A*
(*c*) *A, C, B* (*d*) *B, A, C*
(*e*) *B, C, A*.

Sol. (*d*) In hydrostatic bearings, the surfaces are separated by a film of lubricant forced between them under pressure from an external source pump. The frictional torque is proportional to speed with zero torque at zero speed and thus curve *A* is applicable for it.

In hydrodynamic bearings, the torque is high initially but as speed increases, the torque decreases and when oil film is established then torque increases with increase in speed (Refer curve *C*).

In rolling bearings, initially torque is high but after some speed it is more or less constant (curve *B*).

145. According to the Anit-friction Bearing Manufacturers Association standards, the Rating Life, L_{10} of a group of apparently identical ball/roller bearings is the life in millions of revolutions that 90% of the group will complete or exceed. The value of L_{10} for radial and angular contact ball bearings and radial roller bearings, respectively is proportional to

(*a*) $\left(\frac{C}{P}\right)^2, \left(\frac{C}{P}\right)^{5/2}$ (*b*) $\left(\frac{C}{P}\right)^2, \left(\frac{C}{P}\right)^{11/3}$

(*c*) $\left(\frac{C}{P}\right)^{3/2}, \left(\frac{C}{P}\right)^{4/3}$ (*d*) $\left(\frac{C}{P}\right)^3, \left(\frac{C}{P}\right)^{10/3}$

(*e*) $\left(\frac{C}{P}\right)^4, \left(\frac{C}{P}\right)^{15/4}$

where C = basic load rating and P = equivalent radial load

Sol. (*d*) As per definition, the correct answer is at (*d*).

146. If a flat belt slips and squeals, the most probable reason could be

(*a*) belt is too loose (*b*) belt capacity is insufficient
(*c*) leather surface is too dry and shiny
(*d*) pulley crown is too high, causing increased wear of narrow centre section of belt
(*e*) any one of the above.

Sol. (*e*) The belt may slip and squeal because of any reasons listed at (*a*) to (*d*).

147. Conveyor pulleys are sometimes covered with some form of rubber, fabric, or other lagging material. This lagging is provided in order to
(*a*) increase the coefficient of friction between the belt and pulley
(*b*) reduce wear on the pulley face
(*c*) provide cleaning action, particularly on pulleys in contact with the dirty side of the belt
(*d*) improve traction between the belt and the pulley by providing grooves on lagging, particular for pulleys operating in wet or damp conditions
(*e*) provide deceleration by braking.

Sol. Statements at (*a*) to (*d*) are correct. For braking purpose, mechanic friction brakes, eddy current brakes, dynamic brakes, regenerative brakes, etc. are used.

148. Fig. 80 shows a typical belt conveyor arrangement. This figure shows drive pulley, gravity take up, tail pulley, and return idlers. These are shown by following respectively

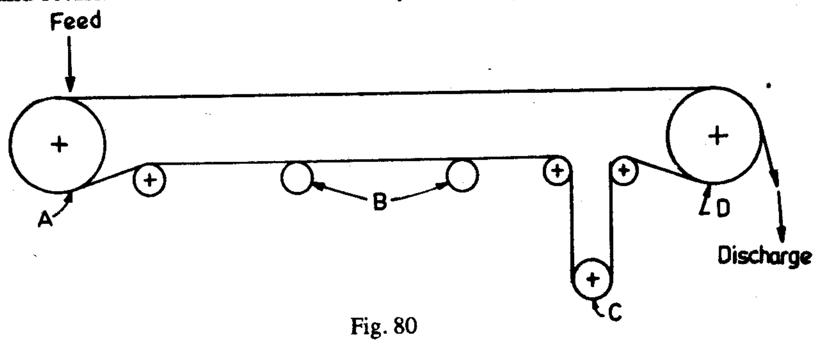


Fig. 80

(*a*) *A, B, C, D* (*b*) *D, C, B, A*
(*c*) *D, C, A, B* (*d*) *A, C, B, D*
(*e*) *D, B, A, C.*

Sol. (*c*) It may be noted that feeding is done near tail pulley and discharge near drive pulley. Therefore *A* is tail pulley and *D* is drive pulley. Return idlers are provided on return path to avoid slack such as by *B*, and vertical gravity take up arrangement is provided to accommodate belt extension and provide uniform tension such as by *C*.

149. The angle of repose of a material is the angle which the surface of a normal, freely formed piles makes to the horizontal. The angle of surcharge is
(*a*) same as angle of repose (*b*) slightly more than angle of repose
(*c*) 5 – 15° more than angle of repose (*d*) slightly less than angle of repose
(*e*) 5 to 15° less than angle of repose.

Sol. (*e*) The angle of surcharge of a material is the angle to the horizontal which the surface of the material assumes while the material is at rest on a moving conveyor belt. This angle is usually 5–15° less than the angle of repose.

150. Fig. 81 shows four angles of surcharge for various materials. The materials being carried are dry silica sand (cement), whole grains (beans), anthracite coal (clay), bagasse (tempered foundary sand).

The figures to hold good for these materials respectively are
(*a*) *A, B, C, D* (*b*) *D, C, B, A*
(*c*) *A, B, D, C* (*d*) *D, C, A, B*

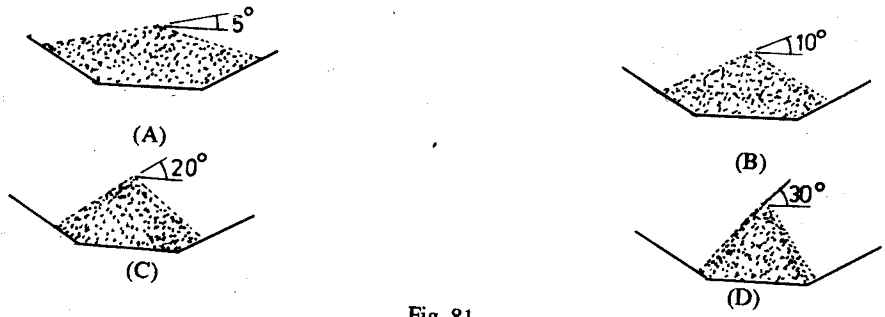


Fig. 81

(e) B, A, D, C.

Sol. (a) The flowability of a material is measured by its angle of repose and angle of surcharge. It is a function of size and shape of fine particles and lumps, roughness or smoothness of the surface of material particles, proportion of fines and lumps present, and moisture content of material. Dry silica sand or cement has uniform size, very small rounded particles and usually very dry. Therefore angle of surcharge is around 5° and thus Fig. (A) is applicable. Whole grain or beans are rounded, dry polished particles of medium weight and thus angle of surcharge is around 10° and Fig. (b) is applicable.

Anthracite coal or clay has irregular, granular or lumpy materials of medium weight which has angle of surcharge of around 20° and thus Fig. (C) is applicable. Bagasses or tempered foundry sand has irregular, stringy, fibrous, inter-locking materials for which angle of surcharge is of the order of 30° and therefore Fig. (D) is applicable.

151. For the following material to be conveyed by belt, the recommended maximum belt speeds can be selected as follows

Material	*Speed*
(A) grain or other free flowing abrasive material	1. 15 to 30 mpm
(B) fine nonabrassive, or muldly abrasive materials	2. 140 to 300 mpm
(C) heavy, hard, sharp-edged one, coarse-crushed stone	3. 60 mpm
(D) prepared foundry sand and similar damp (or dry abrasive) materials.	4. 105 to 180 mpm

(a) A–2, B–1, C–4, D–3
(b) A–1, B–2, C–3, D–4
(c) A–3, B–2, C–1, D–4
(d) A–4, B–1, C–2, D–3
(e) A–2, B–1, C–3, D–4.

Sol. (a) Suitable belt speed depends on the characteristics of the material to be conveyed, the capacity desired and belt tensions used. Powdery materials are conveyed at speeds slow enough to minimise dusting. Fragile materials also limit belt speed. Thus for B, choice is 1.

Heavy, sharp-edged materials are carried at moderate speeds to avoid wear of belt by sharp edges. Thus choice for D is 3 and for C, it is 4. The free flowing abrasive materials can be carried at fast speed and thus choice for A is 2.

152. Pick up false statement about wire ropes.

(a) Wire rope is made up of a number of strands laid helically about a metallic or non-metallic centre

(b) Various types of wire ropes are distinguished by the kind of core, the number of strands : the number, size, and arrangement of the wires in each strand and the way in which the wires and strands are wound or laid about each other.

(*c*) Wire ropes with wire-strand cores are, in general, more flexible than wire ropes with independent wire-rope.
(*d*) Wire-rope cores are made of fibre, cotton, asbestos, polyvinyl plastic, a small wire rope, a multiple-wire strand, or a cold-drawn wire-wound spring
(*e*) Wire rope is specified by length, diameter, no. of strands, no. of wires in each strand, type of rope construction, grade of steel used in rope, whether preformed or not preformed, type of centre, and type of lay.

Sol. (*c*) All statements are correct except (*c*). In fact wire ropes with wire-strand core are, in general, less flexible than wire ropes with independent wire-rope.

153. Pick out the correct statement about wire ropes
(*a*) In the regulay lay, the wires and strands are laid in the same direction
(*b*) In the lang lay, the wires in the strands are laid in the opposite direction to the lay of the strands in the rope
(*c*) The lang lay wire rope is most widely used
(*d*) Regular lay rope has tendency to spin or un-twist when placed under load and is generally selected where lang lay ropes are employed and the loads handled are frequently removed
(*e*) Regular lay ropes have greater flexibility than lang lay ropes and are more resistant to abrasion and fatigue.

Sol. (*d*) All statements except (*d*) are reverse of correct statements.

154. To avoid excessive wear and groove corrugation, the radial pressure exerted by the wire rope on the sheave or drum must be kept within certain maximum limits. If the rope tension is doubled, the tread diameter of sheave or drum should be
(*a*) increased twice
(*b*) increased four times
(*c*) increased $\sqrt{2}$ times
(*d*) increased $1.5\sqrt{2}$ times
(*e*) decreased twice.

Sol. (*a*) Radial pressure on drum or sheave

$$P = \frac{2T}{D \times d}$$

where, (T = rope tension, D = drum diameter, d = rope diameter)

Since T is doubled, to keep same P, D must be doubled.

155. For helical coil springs, spring index is equal to
(*a*) $\frac{\text{coil mean diameter}}{\text{wire diameter}}$
(*b*) $\frac{\text{coil outside diameter}}{\text{wire diameter}}$
(*c*) $\frac{\text{coil internal diameter}}{\text{wire diameter}}$
(*d*) any one of the above
(*e*) none of the above.

Sol. (*a*) In design formula, spring index $= \frac{\text{Coil mean diameter}}{\text{Wire diameter}}$

However, for shop measurement, spring index

$$= \frac{\text{Outside diameter of coil}}{\text{Wire diameter}}$$

and for arbor design, spring index $= \frac{\text{Coil inside diameter}}{\text{Wire diameter}}$

156. For best proportions value of spring index is selected between
(*a*) 3 and 6
(*b*) 4 and 10
(*c*) 4 and 14
(*d*) 6 and 12
(*e*) 8 and 16.

Sol. (*c*) Larger ratios than 14 require more than average tolerances. Ratios of 3 or less, often can not be coiled on automatic spring coiling machines because of arbor breakage. Also, springs with spring index less than 4 and more than 14 do not give the results as calculated from the design formulae.

157. In the case of helical springs, which is not correct.
Deflection is proportional to

(*a*) load (*b*) number of active coils

(*c*) (mean coil diameter)^2 (*d*) $\dfrac{1}{(\text{wire diameter})^4}$

(*e*) $\dfrac{1}{\text{modulus of elasticity in torsion}}$.

Sol. (*c*) Deflection of helical springs is proportional to (mean coil diameter)^3

$$\text{Deflection} = \frac{8PN \cdot D^3}{Gd^4}.$$

158. If the wire diameter, mean of coil, load and number of active coil of a spring are all doubled, its deflection will

(*a*) be doubled (*b*) be halved

(*c*) be $\sqrt{2}$ times (*d*) be $\frac{1}{2}$ times

(*e*) remain same.

Sol. (*a*) Deflection $= \dfrac{8PND^3}{Gd^4}$

New deflection $= \dfrac{8(2P)(2N)(2D)^3}{G(2d)^4} = 2 \times \dfrac{PND^3}{Gd^4}$.

159. If the mean coil diameter of a helical compression spring is doubled, then for same deflection and other parameters being constant, the wire diameter should be increased

(*a*) 2 times (*b*) 4 times

(*c*) $\sqrt[3]{8}$ times (*d*) $\sqrt{2}$ times

(*e*) $\sqrt[3]{4}$ times.

Sol. (*e*) For helical compression spring, $\delta = \dfrac{8ND^3P}{Gd^4}$

where, (δ = linear deflection,
N = No. of active coils,
D = mean coil diameter,
P = load,
G = modulus of rigidity,
d = diameter of wire)

If D is doubled, then for same deflection δ,

$$\frac{D_1^2}{d_1^3} = \frac{(2D_1)^3}{d_2^4}$$

or $$d_2 = 2^{3/4} d_1$$

$$d_2 = \sqrt[4]{8} d_1.$$

160. In the case of flat springs, which is not correct about deflection. Deflection is proportional to

(*a*) L^3 (*b*) P

(*c*) $1/b$ (*d*) $1/E$

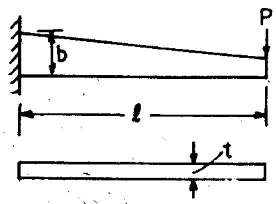


Fig. 82

(e) $1/t^4$.

Sol. (e) Deflection is proportional to $1/t^3$.

161. Four identical steel springs of constant K each are joined together as shown in Fig. 83. The equivalent spring constant of combination is

(a) 2.5 K
(b) 2.4 K
(c) 3 K
(d) 0.8 K
(e) 1.25 K.

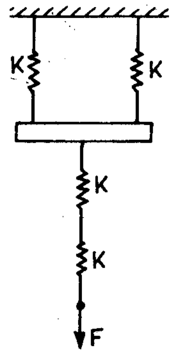


Fig. 83

Sol. (b) Equivalent spring constant $= \dfrac{1}{\dfrac{1}{K+K}+\dfrac{1}{K}+\dfrac{1}{K}} = \dfrac{1}{\dfrac{1}{2K}+\dfrac{2}{K}} = \dfrac{2}{5}K$

$= 0.4\,K.$

162. A torsion bar with a spring constant k is cut into n equal lengths.

The spring constant of each new portion is

(a) k/n (b) nk
(c) k^n (d) $\sqrt[n]{k}$
(e) $\dfrac{k+1}{n}$.

Sol. (b) If a torsion bar is cut into n pieces, then each behaves as if n bars are connected in series

$$\therefore \quad k = \frac{1}{\dfrac{1}{k_1}+\dfrac{1}{k_2}+\dfrac{1}{k_3}+\dfrac{1}{k_n}}$$

Since each new bar has same spring constant, *i.e.*

$$k_1 = k_2 = k_3 = ...k_n$$

$$\therefore \quad k = \frac{1}{\dfrac{1}{k_n}(n)}$$

or $\quad k_n = nk.$

163. A helical spring of constant k is cut into 4 pieces, and the four pieces are then combined in parallel. The equivalent spring constant will be

(a) $\dfrac{k}{16}$ (b) $\dfrac{k}{4}$
(c) $4k$ (d) $16k$
(e) $64k$.

Sol. (d) The spring constant of 4 cut pieces

$= 4 \times k$

when they are put in parallel, new spring constant

$= 4k + 4k + 4k + 4k = 16k.$

164. For a Belleville spring shown in Fig. 84,

(a) $P \propto \dfrac{1}{D_0^2}$ (b) $P \propto \dfrac{1}{D_0}$
(c) $P \propto \dfrac{1}{D_0^3}$ (d) $P \propto \dfrac{1}{D_0^{3/2}}$
(e) $P \propto \dfrac{1}{\sqrt{D_0}}$.

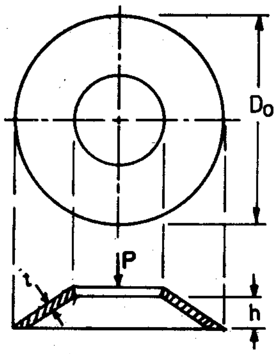


Fig. 84

Sol. (*a*) For a Belleville spring

$$P = \frac{4E\delta}{(1-\mu^2)K_f D_0^2} \times \left[(h-\delta)\left(h-\frac{\delta}{2}\right)t + t^3\right]$$

(E = modulus of elasticity
δ = linear deflection
μ = Poisson's ratio
K_f = factor for Belleville spring
D_0 = outside diameter
h = deflection required to flatten Belleville spring
t = thickness).

165. Fig. 85 shows 2 torsion bars of spring constant $2K$ and K joined together, one being fixed at one end and other at both the ends. Torque T is applied as shown. The equivalent spring constants in these 2 cases will be

Fig. 85

(*a*) $1/3K, 3K$
(*b*) $3K, 1/3K$
(*c*) $2/3K, 3K$
(*d*) $3K, 2/3K$
(*e*) $3K, 3K$.

Sol. (*c*) In first case, system acts as if bars are connected in parallel

$$K_e = \frac{1}{\frac{1}{K}+\frac{1}{2K}} = \frac{1}{\frac{2+1}{2K}} = \frac{2K}{3}$$

In second case, system acts as if bars are connected in series

$\therefore$ $K_e = 2K + K = 3K.$

166. The discharge capacity of a spring loaded safety valve is calculated as

(*a*) $\frac{\pi}{4}D^2$
(*b*) πDL
(*c*) $\frac{\pi}{4}D^2L$
(*d*) $2\pi DL$
(*e*) $4\pi DL$.
(D = diameter; L = lift of valve)

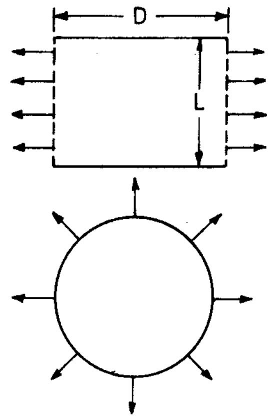


Fig. 86

Sol. (*b*) When valve lifts, the steam leaks from around the cylindrical surface formed between top and bottom. Thus area of discharge is circumference × lift

i.e. $\pi D \times L$

167. A circular beam of radius r is curved in a radius R. For a straight beam, the shear stress s is obtained by the relationship $s = \frac{Mr}{I}$ (M = Bending moment, I = Moment of inertia, r = distance from centroid axis to outer fibre). For a bent beam, shear stress induced is found by multiplying 's' by a factor K.

The values of K for inner fibre and outer fibre are correctly represented in the following part of Fig. 87.

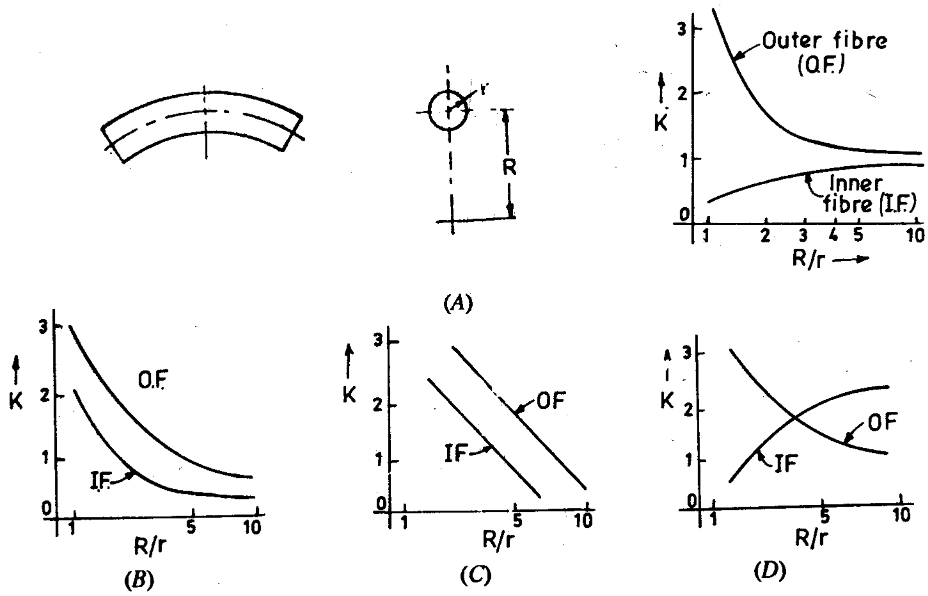


Fig. 87

(*a*) *A* (*b*) *B*

(*c*) *C* (*d*) *D*

(*e*) none of the above.

Sol. (*a*) Correct curve is *A*. For values of *R*/*r* greater than 10, beam acts like a straight beam and so values of *K* have to be nearly 1.

168. Minimum number of teeth required on spur gear for no undercutting is equal to

(*a*) $\frac{1}{\sin \phi}$ (ϕ = pressure angle)

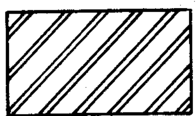
(*b*) $\frac{1}{\sin^2 \phi}$ (*c*) $\frac{1}{\sin^2 2\phi}$

(*d*) $\frac{2}{\sin^2 \phi}$ (*e*) $\frac{2}{\sin 2\phi}$.

Sol. (*d*) The correct answer is $\frac{2}{\sin^2 \phi}$.

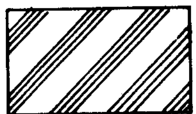
169. Fig. 88 shows some of the commonly used symbols for section linings as per ANSI standard.

(*a*) Cast or malleable iron and general use for all materials



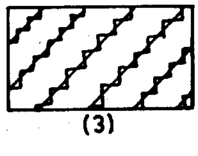
(1)

(*b*) Steel



(2)

(*c*) Marble, slate, glass, porcelain, etc.



(3)

(*d*) Thermal insulation

(*e*) Rubber, plastic, electrical insulation.

The correct sequence of 1, 2, 3, 4 and 5 is
(*a*) *B, E, D, C, A*
(*b*) *B, D, E, A, C*
(*c*) *E, B, D, A, C*
(*d*) *A, D, B, C, E*
(*e*) *D, B, C, A, E.*

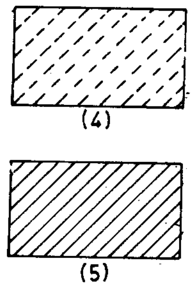


Fig. 88

Sol. (*a*) It is important to memorise some of the commonly used symbols for section lining. The correct sequence here is 1–*B*, 2–*E*, 3–*D*, 4–*C*, 5–*A*.

170. Fig. 89 shows some of the commonly used symbols for geometric characteristics and tolerances on detail drawings as per ISO standards

(1) (*A*) Symmetry
(2) (*B*) Total runout
(3) (*C*) Cylindricity
(4) (*D*) Position
(5) (*E*) Diameter

Fig. 89

The correct order for symbols 1, 2, 3, 4, and 5 is
(*a*) *D, A, E, C, B* (*b*) *E,, B, D, C, A*
(*d*) *D, A, C, B, E* (*d*) *A, D, C, E, B*
(*e*) *D, E, A, B, C.*

Sol. (*a*) The correct order is

1–*D*, 2–*A*, 3–E, 4–*C*, 5–*B*.

171. Arrange the following materials in descending order in regard to their yield stress
(*A*) Mild steel, (*B*) Bronze
(*C*) Copper (*D*) Magnesium alloy
(*E*) Brass.
(*A*) *C, A, B, D, E* (*b*) *A, C, B, D, E*
(*c*) *B, A, D, C, E* (*d*) *B, A, C, D, E*
(*e*) *A, C, D, B, E.*

Sol. (*e*) The correct values of yield stress are

(*a*) Mild steel	248 MPa
(*c*) Copper	245 MPa
(*d*) Magnesium alloy	139 MPa
(*b*) Bronze	138 MPa
(*e*) Brass	103 MPa.

172. Zeolite (naturally occurring or artificial hydrated aluminium silicate) is used for

(*a*) TIG welding process (*b*) continuous casting process
(*c*) lubricating cutting fluid (*d*) softening water
(*e*) production of aluminium.

Sol. (*d*) Water hardness is caused by the presence of dissolved calcium and magnesium salts. Zeolite removes calcium ions by making calcium aluminium silicate and releasing sodium ions,

$$\underset{\text{(Zeolite)}}{2NaSi\,AlO_4} + \underset{\text{(Calcium ions)}}{Ca^{++}} \longrightarrow Ca\,(AlSiO_4)_2 + 2Na^+$$

173. A veneer is a
(*a*) thin layer of expensive decorative wood which is glued to a base of other wood
(*b*) protective coating applied on the surface of a cutting tool
(*c*) additive mixed with cutting fluid to increase lubrication
(*d*) non-corrosive layer applied over the surface of iron
(*e*) scent mixed in water in air conditioned space.

Sol. (*a*) Solid timber pieces of furniture and decorative wood panelling are often veneered because this makes possible an attractive finish at a saving in cost, since the base can be made of cheaper wood.

174. Fig. 90 shows the pressure and temperature withstand characteristics of commonly used materials, *viz.*, stainless steel, aluminium, brass, nickel, and low carbon steel.

The correct curves for these materials are
(*a*) *C, E, D, A, B*
(*b*) *C, E, D, B, A*
(*c*) *A, D, B, C, E*
(*d*) *A, E, D, C, B*
(*e*) *A, E, D, B, C.*

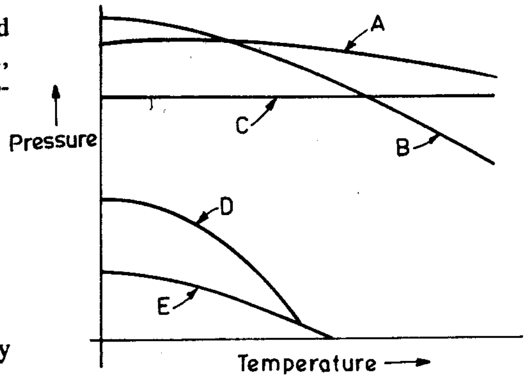


Fig. 90

Sol. (*a*) It may be noted that stainless steel has nearly constant pressure withstand capability at all temperatures but it is lesser than those of nickel. Nickel has maximum capability for high pressure-temperature withstanding. Low carbon steel has higher capability at lower temperatures but it falls at higher temperatures. Brass and aluminium are nowhere in comparison to nickel, stainless steel and low carbon steel. But brass is better than aluminium.

175. The magnetising force that must be applied in the direction opposite to that of the previous magnetising force in order to remove residual magnetism, is called
(*a*) cohesive force (*b*) coercive force
(*c*) fatigue back (*d*) elastic hysteresis force
(*e*) flow force.

Sol. (*b*) The correct answer is coercive force which is also an indicator of the "strength" of magnetically hard materials.

176. Arrange the following in the decreasing order of their critical point
(*a*) Air (*b*) Oxygen (*c*) Helium (*d*) Hydrogen (*e*) Krypton.
(*a*) *E, B, A, D, C* (*b*) *C, D, A, B, E*
(*c*) *E, A, B, C, D* (*d*) *A, B, E, D, C*
(*e*) *B, A, E, C, D.*

Sol. (*a*) The critical temperatures of these elements are as under

Krypton	210.1 °K	Oxygen	154.3 °K
Air	132.5 °K	Hydrogen	33.2 °K
Helium	3.34 °K.		

177. Damping capacity is defined as the energy dissipated as heat by a unit volume of the material during a completely reversed cycle of stress.

Fig. 91 shows three curves of different materials *viz.* alloy steel, carbon steel and cast iron. The curves applicable for these are

(*a*) *A, B, C*
(*b*) *C, B, A*
(*c*) *C, A, B*
(*d*) *A, C, B*
(*e*) *B, A, C.*

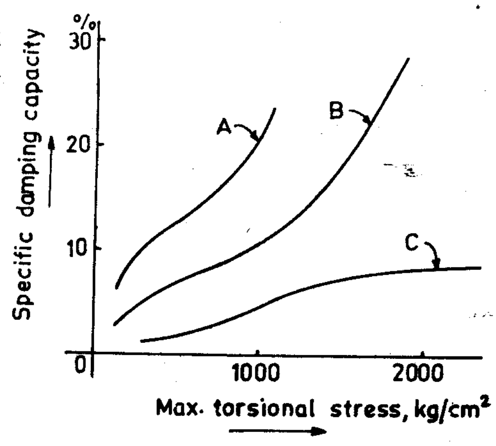


Fig. 91

Sol. (*b*) Cast iron has high damping capacity at lower maximum torsional stress and is thus used for machine members in machine tools to reduce vibration/chatter/noise. It is represented by curve *A*.

Alloy steel has low damping capacity even at high value of maximum torsional stress. It is thus suitable where resonance is required as for tuning fork, bells, etc. It is represented by curve *C*.

Carbon steel lies in between cast iron and alloy steel, and is represented by curve *B*.

178. The piping of following material should never be used with acetylene

(*a*) brass (*b*) aluminium
(*c*) copper (*d*) mild steel
(*e*) stainless steel.

Sol. (*c*) Copper piping in the presence of acetylene forms copper acetylide, an unstable compound that disassociates violently at the slightest shock and therefore must never be used.

179. Fig. 92 shows an example of

(*a*) back hand welding
(*b*) fore hand welding
(*c*) left hand welding
(*d*) right hand welding
(*e*) normal welding.

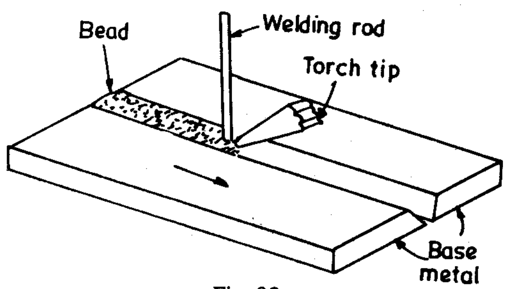


Fig. 92

Sol. (*a*) In back hand welding the torch is held at an angle of 30–45° with the work, and the flame is directed back over the portion of the work that has been welded.

180. In which of the following resistance welding, the heating of the metals to be welded occurs over their entire surface area by an electrical discharge and the force is applied immediately after the electric discharge occurs between the adjoining surface

(*a*) shot welding (*b*) upset welding
(*c*) flash welding (*d*) spike welding
(*e*) percussion welding.

Sol. (*a*) Shot welding is a special spot welding in which a carefully controlled amount of current is used for a very brief interval.

In upset welding heavy current is passed from one piece to other, and the resistance to electrical flow heats the faces to fusion temperature.

Flash welding is a form of butt welding which uses considerable pressure to join the parts together, when the plastic temperature of the metal is reached.

Spike welding is a type of resistance welding which uses maximum energy and minimum time.

The correct answer is percussion welding.

181. Shown below are cross-sections of various mill or saw type files. Match part *A* and *B*.

A		*B*
1. Web saw files	(I)	
2. Mill files	(II)	
3. Double ender files	(III)	
4. Cross cut files	(IV)	
5. Cantsaw files	(V)	

Fig. 93

The correct sequence for 1–5 to

(*a*) *I, II, III, IV, V* (*b*) *V, IV, III, II, I*

(*c*) *I, II, IV, III, V* (*d*) *V, IV, II, III, I*

(*e*) *V, IV, III, I, II.*

Sol. (*b*) The correct sequence is

1–*V*, 2–*IV*, 3–*III*, 4–*II*, 5–*I*.

182. Two columns below indicate various classes of files and their description. Match them properly.

(*I*)	(*II*)
1. Mill or saw file	(*A*) Used for removal of metal and where finish is not that important, Mostly these are double cut.
2. Machinist file	(*B*) Employed for work on relatively soft substances such as wood, leather, for fast removal.
3. Curved tooth file	(*C*) Used by tool and die makers, model makers and delicate instrument finishers. Made to closer tolerances.
4. Swiss pattern file	(*D*) Used for sharpening mill or circular saws : for lathe work; for draw filing; for smooth filing.
5. Rasps	(*E*) These are made in both rigid and flexible forms. These come in standard, fine and smooth cuts.

The correct sequence for 1—5 is

(*a*) *D, A, E, C, B* (*b*) *A, D, C, E, B*
(*c*) *B, A, C, D, E* (*d*) *B, D, A, C, E*
(*e*) *E, A, D, C, B.*

Sol. (*a*) The correct sequence is 1–*D*, 2–*A*, 3–*E*, 4–*C*, 5–*B*.

183. Pick up the wrong statement about provision of clearance on punches and dies in press work.

(*a*) The amount of clearance between a punch and die for blanking and perforating is governed by the thickness and kind of stock to be operated upon.
(*b*) For thin material, the punch should be a close sliding fit, as otherwise, the punching will have ragged edges.
(*c*) The clearance between the punch and die in cutting heavy material, lessens the danger of breaking the punch and reduces the pressure required for the punching operation
(*d*) When holes of a given size are required, the die is made to the diameter wanted and punch is made smaller
(*e*) Clearance not only affects the smoothness of the fracture, but also the pressure required for punching or blanking.

Sol. (*d*) Statement at (*d*) is wrong because for obtaining holes of given size, punch is made to the diameter wanted and the die is made larger. The statement given holds when a blank of given size is required.

184. If the diameter of a finished round cornered cup is to be 4 cm and the height 3 cm, and radius of corner is around 0.5 cm, then the trial diameter of the blank should be

(*a*) 5.5 cm (*b*) 6.5 cm
(*c*) 7.5 cm (*d*) 8.5 cm
(*e*) 9.5 cm.

Sol. (*c*) Diameter of blank $D = \sqrt{d^2 + 4dh} - r$

(d = diameter of shell
h = height
r = radius of the corner

$= \sqrt{4^2 + 4 \times 4 \times 3} - 0.5$
$= \sqrt{16 + 48} - 0.5$
$= \sqrt{64} - 0.5 = 8 - 0.5 = 7.5$ cm.

185. The parameters *A*, *B* and *C* on a broach shown in Fig. 94 are called

(*a*) face angle, land, clearance angle
(*b*) clearance angle, land shear angle
(*c*) shear angle, depth, clearance angle
(*d*) rake, radius, shear angle
(*e*) face angle, depth, shear angle.

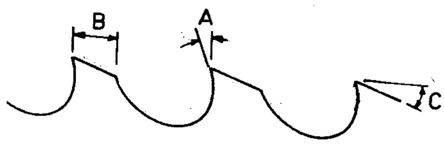


Fig. 94

Sol. (*a*) The correct terminology is as per (*a*).

186. As a general rule, to give satisfactory performance, the number of teeth in milling cutters should be such that no more than two teeth at a time are engaged in the cut. Based on this rule, the recommended teeth for face milling cutters and peripheral milling cutters respectively are

(*a*) $\dfrac{6.3W}{D}, \dfrac{D+4d}{12.6D\cos A}$ (*b*) $\dfrac{D}{W}, \dfrac{2\pi D\cos A}{D+2d}$

(*c*) $\dfrac{D}{3.1W}, \dfrac{6D\cos A}{D+d}$ (*d*) $\dfrac{D}{6.3W}, \dfrac{12.6D\cos A}{D+4d}$

(*e*) $\dfrac{D}{12W}, \dfrac{16.2D\cos A}{D+4d}$

where, (D = diameter of cutter, W = width of cut
d = depth of cut, A = helix angle of cutter).

Sol. (*d*) The correct relationship is as given at (*d*).

187. The lead of milling machine is equal to revolute of feed screw for one revolution of index spindle with equal gears × lead of feed screw

The ratio $\frac{\text{lead of helix to be cut}}{\text{lead of milling machine}} =$

(*a*) $\frac{\text{product of no. of teeth of driven gears}}{\text{product of no. of teeth of driving gears}}$

(*b*) $\frac{\text{product of no. of teeth of driving gears}}{\text{product of no. of teeth of driven gears}}$

(*c*) $1 + \frac{\text{product of number of teeth of driver gears}}{\text{product of number of teeth of driving gears}}$

(*d*) $\pi \times \frac{\text{product of number of teeth of driven gears}}{\text{product of number of teeth of driving gears}}$

(*e*) $\frac{\text{product of number of driven gears}}{\text{product of number of driving gears}} - 1.$

Sol. (*a*) The correct relationship is at (*a*).

188. Given below are two parts

(*A*)	(*B*)
(I) The algebraic difference between a size and the corresponding basic size	1. Tolerance
(II) The difference between the maximum and minimum size limits on a part	2. Deviation
(III) That one of the two deviations closest to the basic size	3. Upper deviation
(IV) The algebraic difference between the minimum limit of size and the corresponding basic size	4. Fundamental deviation
(V) The algebraic difference between the maximum limit of size and the corresponding basic size.	5. Lower deviation

The correct correspondence of I, II, III, IV, and V under *A* is with the following under *B*.

(*a*) 1, 2, 4, 3, 5 (*b*) 2, 1, 4, 5, 3
(*c*) 2, 1, 5, 3, 4 (*d*) 4, 5, 3, 2, 1
(*e*) 3, 5, 4, 1, 2.

Sol. (*b*) The correct matching is
I–2, II–1, III–4, IV–5, V–3.

189. For planer drive where low speed is desired for cutting stroke and high speed for return stroke, which of following type of DC motor would you prefer

(*a*) Series-wound DC motor (*b*) Shunt wound DC motor
(*c*) Adjustable voltage shunt wound DC motor
(*d*) Compound wound DC motor (*e*) none of the above.

Sol. (*b*) Shunt wound motors have constant horsepower characteristics which permits heavy cuts at low speed and light or finishing cuts at high speed. Thus they are ideally suited for applications like machine tool spindle drives and for planer, etc.

190. Friction or "play" between elements of an instrument are direct causes of
(a) hysteretic error
(b) dead band
(c) repeatability
(d) linearity
(e) drift.

Sol. (b) It may be noted that dead band represents the range through which an input can be varied without initiating response. It is only friction or "play" between elements of an instrument which may change input with no force or motion available to the driven element.

Further hysteresis occurs due to energy absorption in the elements of a measuring instrument.

The repeatability refers to the closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions, approaching from the same direction for full range traverses. This is not covered fully by friction only.

Linearity represents the closeness to which an input-output curve approximates a straight line, which again does not depend on friction alone. Drift refers to a change in the output-input relationship over a period of time and is the result of several other factors.

191. The smallest change in the input signal that will result in a measurable change in the output signal of an instrument is referred to as
(a) resolution
(b) accuracy
(c) sensitivity
(d) repeatability
(e) threshold.

Sol. (e) The correct answer is threshold. It may be noted that all items look alike but one must understand the difference between these terms exactly. Resolution refers to the degree to which equal values of a quantity can be discriminated by the instrument. Accuracy refers to the conformity of an indicated value to an accepted standard value, or true value.

Sensitivity refers to the ratio of a change in output magnitude to the change of input which causes it after the steady-state has been reached.

Repeatability is the closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions, approaching from the same direction for full range traverses.

192. Hygrometers are used to measure
(a) flow
(b) density
(c) velocity
(d) relative humidity
(e) viscosity.

Sol. (d) Hygrometer measures relative humidity. It is based on change in dimensions of a hygroscopic material such as human hair, wood or paper with change in relative humidity.

193. Which of the following instrument is more suitable for measuring higher ranges of water flow in the midstream of river
(a) pitot tube
(b) venturimeter
(c) cup-type current meter
(d) sharp-crest weir
(e) propeller-type current meter.

Sol. (e) Pitot tube is used for measuring velocity of flow in conduits

Venturimeter is used to measure flow in pipes.

Cup-type current meter is used to measure speed of water current and not suited for high flow in mid stream.

Sharp-crest weir is used to measure flow in open channel.

Thus all these devices are not suited. Most suited device to measure high range of water flow in mid-stream is propeller-type current meter.

194. One torr pressure is equal to, and a suitable instrument to measure 10^{-3} to 10^{-11} torr pressure is
(*a*) 1 mm of mercury column, hot filament ionisation gauge
(*b*) 1 mm of water column, cold filament magnetron
(*c*) 1 micron of mercury column, alpha source ionisation gauge
(*d*) 1 micron of water column, Mcleod gauge
(*e*) 10 mm of mercury column, Knudsen gauge.

Sol. (*a*) 1 torr is the pressure exerted by a mercury column 1 mm high. The hot-filament ionisation gauge is the most widely used pressure measuring device for the region from 10^{-3} to 10^{-11} torr.

195. The instrument based on the following principle is used only for measurement of oxygen content in flue gases
(*a*) chemical absorption
(*b*) thermal conductivity
(*c*) infrared absorption
(*d*) paramagnetism
(*e*) ultraviolet radiation.

Sol. (*d*) Instrument based on paramagnetism is used for measurement of O_2 only. Chemical absorption principle is used in old instruments for measurement of both CO_2 and O_2. Thermal conductivity principle is used for measuring CO_2, H_2 purity in water analysis, etc. Infra red absorption principle is used for measuring CO and other gases. Ultraviolet radiation detectors are used to sense presence of flame.

196. The most commonly used method of leak detection on high vacuum (of the order of 10^{-9} pascal) equipment is by means of
(*a*) capsule gauge
(*b*) thermal conductivity gauge
(*c*) Pirani or thermocouple type gauge
(*d*) ionisation gauge
(*e*) mass spectrometer or Tesla coil.

Sol. (*e*) Capsule gauge using a thin diaphragm is used for measuring a low vacuum (100 pascal below atmospheric pressure).

Thermal conductivity gauge (or Pirani or thermocouple type gauge) is used for measuring 1000 to 0.1 pascal vacuum range.

Ionisation gauge is used for higher vacuum regions.

For high vacuum (10^{-9} pascal), mass spectrometer, or Tesla coil is used. Mass spectrometer analyses the components of a gas by the deflection on them caused by a magnetic field. The outside of the vacuum system is covered by a light plastic bag filled with helium gas and a probe sensing helium gas is used to locate the leak. When helium enters the system through leak, spectrometer registers increased concentration of helium.

Tesla coil produces a high voltage, and if brought close enough to the outside of a glass tube, will cause any gas in it to glow.

197. Eddy current coupling is an electromagnetic device placed between the squirrel cage motor and speed reducer, and provides an ideal means of controlled acceleration. Pick out false statement about it
(*a*) The degree of excitation of coil by low power determines the slip between the driving and driven members
(*b*) It permits smooth, controlled starting
(*c*) It permits starting and accelerating of motor without connecting the load
(*d*) It requires no water cooling and is cheap compared to wound-rotor motor
(*e*) If permits variable speed operation.

Sol. (*d*) The attributes at (*a*), (*b*), (*c*), and (*e*) are the advantages and statement at (*d*) is wrong. When eddy current drive is used for variable speed application, the additional slip creates more heat, which has to be dissipated by cooling water supply. Further it is more expensive than a wound rotor motor because of additional features incorporated.

198. Given below are the definition of various types of torques encountered with electrical motors.

A	*B*
I. Minimum torque a motor will develop at rest for all angular positions of the rotor, with rated voltage applied at rated frequency.	(1) Break-down torque
II. Maximum torque which the motor will develop, with rated voltage applied at rated frequency, without an abrupt drop in speed.	(2) Pull-up torque
III. Maximum sustained torque which a synchronous motor will develop at synchronous speed with rated voltage applied at rated frequency and with normal excitation.	(3) Pull-in torque
IV. Maximum constant torque under which the synchronous motor will pull its connected inertia load into synchronism at rated voltage and frequency, when its field excitation is applied.	(4) Locked rotor torque
V. Minimum torque developed by the motor during the period of acceleration from rest to the speed at which break-down torque occurs.	(5) Pull-out torque

The correct sequence for I, II, III, IV, and V is
(*a*) 4, 1, 3, 5, 2 (*b*) 1, 4, 5, 2, 3
(*c*) 3, 2, 1, 4, 5 (*d*) 4, 1, 5, 3, 2
(*e*) 2, 3, 5, 1, 4.

Sol. (*d*) The right answer is

I–4, II–1, III–5, IV–3, V–2.

199. Which of the following type of direct current motor is best suited for applications like traction and lifting service where load is practically constant
(*a*) Series wound DC motor (*b*) Shunt wound DC motor
(*c*) Adjustable voltage shunt wound DC motor
(*d*) Cumulative compounding DC motor
(*e*) Differential compounding DC motor.

Sol. (*a*) In series wound motor, as the load is decreased the field is weakened and speed increases. At very light loads, speed becomes excessive. Thus this motor is suited where loads are practically constant as in traction and lifting service.

200. Noise is considered to be big nuisance and most distracting factor in industries. As per international practice, acceptable value of noise level in industrial environment is
(*a*) 185 db at 10 m (*b*) 110 db at 5 m
(*c*) 85 db at 1.5 m (*d*) 60 db at 1.0 m
(*e*) 40 db at 0.5 m.

Sol. (*c*) It may be noted that decibell (db) scale is on logarithmic base and 1 db increase means value is doubled from previous value. Please note that 185 db is very high noise level and 40 db too small. The level permitted is 85 db as measured at a distance of 1.5 metre from the source of noise.

MATCH THE TWO PARTS

1.1. Match parts A and B relating to thermodynamics.

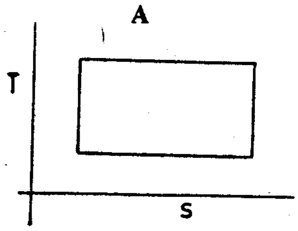
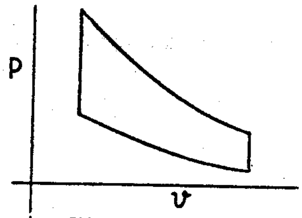
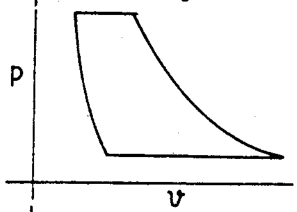
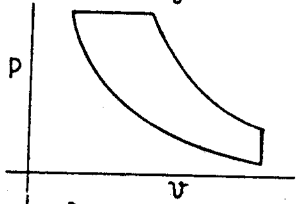
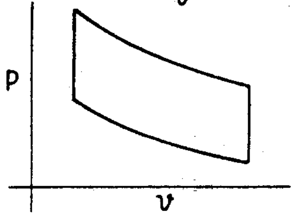
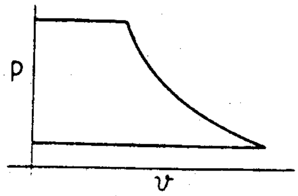
A	B
1. Heat of fusion, vaporisation, sublimation, and changes in crystal form are examples of	(*a*) Cycle
2. At a specified temperature, a pure liquid can exist in equilibrium contact with its vapour at only one pressure	(*b*) Latent effects
3. The quantity of matter under consideration in thermodynamics is called	(*c*) Steady flow process
4. Any process or series of processes in which the system returns to its original condition or state is called	(*d*) Closed System
5. If there is no interchange of matter between system and surroundings, it is called	(*e*) Second law of thermodynamics
6. Whenever energy is transformed from one system to another, energy is always conserved.	(*f*) Vapour pressure
7. The mass rate of flow into the system is equal to the mass rate of flow out, and conditions in the system do not change with time.	(*g*) Vander Waals equation
8. Conversion of heat to work is limited by the temperature at which conversion occurs.	(*b*) Dalton's law
9. Modification of the ideal gas law which is useful at high pressure.	(*i*) System
10. The total pressure of the mixture is the sum of the partial pressures.	(*j*) First law of thermodynamics

1.2. Match parts A and B in regard to thermal properties of substances

A	B
1. For ordinary use upto 500°F, the international temperature scale is closely approximated with	(*a*) One Calorie
2. The condition under which three phases of matter can coexist in equilibrium.	(*b*) 1.66
3. In hydrogen thermometer, zero pressure corresponds to	(*c*) 6.4
4. $\frac{1}{860}$ watthour is equal to	(*d*) 1.40
5. For elements near room temperature, the specific heat at constant volume for one atomic weight of any solid element is	(*e*) – 273.15°
6. For monatomic gases, the specific heats do no vary with temperature and value of $K\left(i.e. \frac{C_p}{C_v}\right)$ may be taken as	(*f*) Triple point

7. For diatomic gases (O_2, N_2 etc.), the specific heats (K) vary with temperature but for many purposes may be assumed constant over considerable ranges of temperature. Value of K may be taken as — (*g*) Mol basis
8. One mole of any perfect gas contains the same number of molecules — (*h*) Latent effects
9. Properties of gases are, usually, most readily correlated on — (*i*) Mercury thermometer
10. For pure substances, the heat effects accompanying changes in state at constant pressure — (*j*) Avogadros' principle

1.3. Match the following ideal cycles

A	B
1. 	(*a*) Diesel Cycle
2. 	(*b*) Stirling Cycle
3. 	(*c*) Carnot Cycle
4. 	(*d*) Air Compressor Cycle
5. 	(*e*) Joule or Barton Cycle
6. 	(*f*) Otto Cycle

1.4. Match the two parts regarding direct energy conversion

A	B
1. A current is produced in a closed circuit of two dissimilar metals if the two junctions are maintained at different temperatures	(*a*) Fuel cell
2. A vacuum or gas filled device with a hot electron emitter (cathode) and a cold electron collector (anode) in or as a part of a suitable gastight enclosure, with electrical connections to the anode and cathode, and with means for heating the cathode and cooling the anode.	(*b*) Solar cell
3. An electrochemical device in which electrical energy is generated by chemical reaction without altering the basic components of the cell.	(*c*) MHD generation
4. It utilises the movement of electrically conducting gas through a magnetic field	(*d*) Silicon cell
5. Utilises the direct conversion of light energy into electrical energy.	(*e*) Photo voltaic effect
6. It consists of a silicon wafer of '*n*' material $1 \text{ cm} \times 2 \text{ cm} \times \frac{1}{2}$ mm thick and having a thin layer (several microns) of boron ('*p*' material) diffused on the side to be exposed to light.	(*f*) Peltier effect
7. Widely used in space power systems where their long life and light weight are important considerations.	(*g*) Magneto hydrodynamic generation
8. It involves the heating or cooling of the junction of the thermoelectric materials by passing current through the junction.	(*h*) Thermoelectric generation
9. Generation of electric potential by the ionisation by light energy (photons) in the area at or near the *p-n* junction of a semiconductor.	(*i*) Photo voltaic generation
10. Compared of other methods of direct conversion, __________ appears to be best suited for generation of large blocks of power.	(*j*) Thermionic generation

1.5. Match parts A and B relating to unconventional methods of energy generation

A	B
1. Sun's radiation is absorbed and converted into heat which is then used to heat.	(*a*) Helio-electric
2. Shorter wavelengths from sun cause chemical reactions, sustain growth of plants and animals, convert CO_2 to O_2 by photosynthesis, and cause degradation and fading of fabrics, plastics and paint.	(*b*) Solar
3. Part of the solar energy between 0.33 and 1.3 μm can be converted directly into electricity by photo voltaic cells.	(*c*) Helio-thermal
4. Used to measure the total radiation from sun and sky.	(*d*) Wave motors

5. __________ sites, historically have been identified from obvious surface manifestations such as hot springs, fumarole and geysers.	(*e*) Photosynthesis
6. The __________ are renewable sources of energy originating in the gravitational pull of the moon and sun coupled with the rotation of the earth.	(*f*) Hydrogen
7. __________ depend for their operation largely on the lifting power of the waves.	(*g*) Geothermal
8. Vegetation offers, by __________, a natural process for the storage of solar energy.	(*h*) Helio-chemical
9. __________ offers many attractive properties for use as fuel in a power plant.	(*i*) Tides
10. __________ air-conditioning and refrigeration can be achieved with absorption system supplied with moderately high temperature working fluids (120°C) from high-performance flat-plate collectors.	(*j*) Pyranometer

1.6. Match the two parts relating to I.C. engines.

A	B
1. The compression ratio for spark ignition engines varies from 6 : 1 to 12 : 1. It is limited by the __________	(*a*) Compression ignition or diesel cycle.
2. __________ in the I.C. engines is produced by the spontaneous combustion or auto ignition of an appreciable portion of the charge.	(*b*) two stroke cycle engines.
3. __________ temperature of an air fuel mixture is the lowest temperature at which chemical reaction proceeds at a rate sufficient to result eventually (long time lag) in inflammation.	(*c*) Spark ignition or otto cycle
4. Spark advance is measured by the number of degrees the crankshaft rotates between the time of the spark and the end of the compression stroke. Optimum spark advance is the timing which __________	(*d*) rotary engines.
5. Tetraethyl lead is the most effective knock suppressor. However its addition is being eliminated because of its __________	(*e*) knock of the fuel air mixture
6. A triangular motor rotates on an eccentric shaft inside an epitrochoidal housing; the rotor tips being in constant contact with the housing and forming three working chambers	(*f*) compression ignition engine
7. Blowers or compressors are often used for scavenging and supercharging in the case of	(*g*) auto ignition
8. The compression pressure obtainable is 27 to 48 kg/cm^2. This engine could be	(*h*) adverse effects on exhaust emissions
9. Combustion process at constant volume occurs in	(*i*) develops maximum torque
10. Combustion process at constant pressure occurs in	(*j*) combustion knock

1.7. Match the two parts in regard to I.C. engines.

A	B
1. The nominal compression ratios of spark ignition engines have dropped from a high of 10.5 : 1 to 8 : 1. This is in order to reduce ______	(*a*) tetraethyl lead
2. The octane number of a fuel is the percentage by volume of iso-octane in a mixture of iso-octane and ______ which matches the unknown fuel in knock tendency.	(*b*) rich
3. A fuel that knocks less than iso-octane is rated by the amount of ______ in iso-octane required to match the knock of the unknown fuel.	(*c*) heptamethyl-nonane.
4. The cetane number (C.N.) of a diesel fuel is determined by matching its ignition quality with that of a blend of two reference fuels, normal cetane (C.N = 100) and ______ (C.N. = 15).	(*d*) diesel engine.
5. The ______ scale for aviation gasolines is designed to relate fuel rating to average knock-limited performance.	(*e*) lean
6. The ______ of a fuel for a compression ignition engine is indicated by the time lag between beginning of injection and start of rapid pressure rise caused by combustion.	(*f*) normal heptane
7. The factors that tend to aggravate knocking in a spark ignition gasoline engine tend to suppress it in a ______	(*g*) performance number.
8. In S.I. engines, a ______ mixture is required for idling.	(*h*) NO_x in exhaust gases
9. In S.I. engines, maximum economy is obtained with ______ mixtures.	(*i*) CO and hydrocarbons in exhaust gases.
10. The rich mixture which provides maximum power, gives large amounts of ______	(*j*) ignition quality

1.8. Match the two parts in regard to I.C. engines.

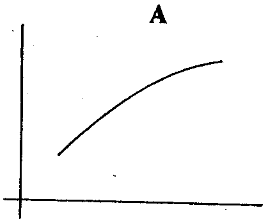
A	B
1. ______ is required to overcome the resistance to flow of fresh charge into and exhaust products out of the cylinder	(*a*) idle
2. High manifold and cylinder temperatures and resistance to flow reduce ______	(*b*) engine power
3. The principal source of exhaust CO is ______ combustion	(*c*) volumetric efficiency
4. The conditions like wall quenching, incomplete combustion, wall deposits, leakage, and scavenging loss result in ______	(*d*) distributor
5. Diesel engines require a speed governor to provide a stable ______	(*e*) nozzle

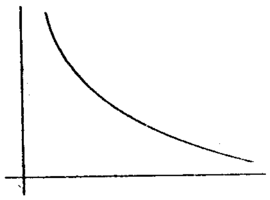
6. ________ distribute the air or the air and fuel to the various cylinders of multicylinder engines	(*f*) pumping work
7. The ignition system consists usually of a 12 V storage battery, induction coil, and high tension ________	(*g*) mixture distribution
8. The fuel-injection system for diesel engines usually consists of a pump, fuel line, and ________	(*h*) hydro-carbon emission
9. The CO, CO_2 and O_2 analyses of the exhaust gases from the individual cylinders and spark plug temperatures may be used for determination of ________	(*i*) rich mixture
10. Supercharging permits more fuel to be burned and is a practical means to produce greater ________	(*j*) intake manifolds

1.9. Match the two parts relating to spark ignition engines.

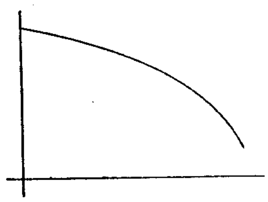
A	B
1. The ________ atomises, and mixes the fuel with the air flowing to the engine	(*a*) maximum power mixture
2. A ________ is required for idling and small throttle openings because of dilution of the small incoming charge with the exhaust gases in the clearance space.	(*b*) air bled
3. A ________ is desired at intermediate loads.	(*c*) carburettor
4. A ________ is usually desired at wide open throttle	(*d*) idling
5. Maximum economy is obtained with ________	(*e*) exhaust valve
6. The ________ jet in carburettor has suction with the engine idling and the throttle closed.	(*f*) rich mixture
7. The increasing richness accompanying increase in throttle opening, which is characteristic of the simple carburettor, is usually compensated by a restricted/ unrestricted ________ jet.	(*g*) minimum
8. Spark plugs are usually located near ________ so that the flame progresses toward the cooler part of the combustion chamber.	(*h*) lean mixtures
9. Maximum power air-fuel ratios require the ________ spark advance.	(*i*) more
10. High speed automotive engines in comparison to low-speed engines require ________ spark advance.	(*j*) maximum economy mixture

1.10. Match the characteristic curves in part A with description in part B in regard to I.C. engines

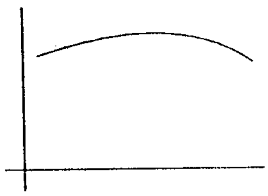
A	B
1. 	(*a*) Ratio of fuel-air cycle η to air cycle η *vs* fuel air ratio.

2. 

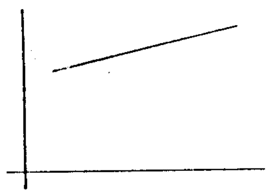
(*b*) Volumetric efficiency *vs.* piston speed

3. 

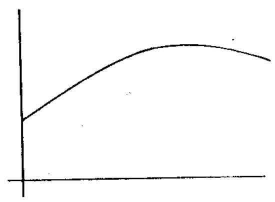
(*c*) Ratio of mean effective pressure to maximum pressure *vs.* pressure ratio.

4. 

(*d*) Mean gas temperature versus fuel air ratio.

5. 

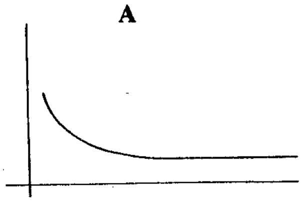
(*e*) efficiency *vs.* pressure ratio for air cycle

6. 

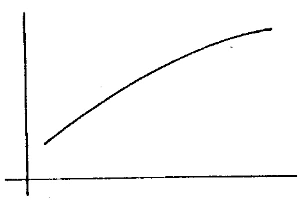
(*f*) Ratio of maximum and minimum temperatures in air cycle *vs* compression ratio.

1.11. Match figures in part A with description in part B relating to performance of I.C. engines :

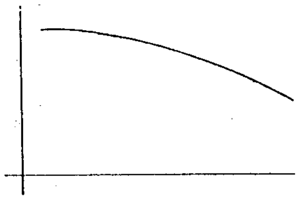
A	B

1. 

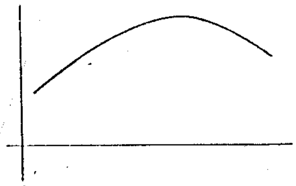
(*a*) Torque *vs.* Engine speed for 2 cycle diesel engine

2. 

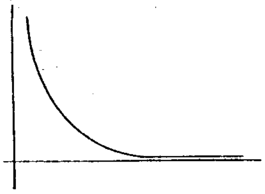
(*b*) % of CO in exhaust gases *vs.* air fuel ratio

3. 

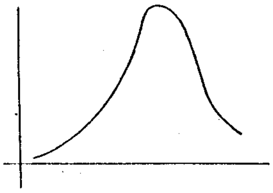
(*c*) Nitrogen oxide in exhaust gases *vs.* air fuel ratio

4. 

(*d*) Brake h.p. *vs.* speed for 2-stroke diesel engine

5. 

(*e*) Specific fuel consumption *vs.* speed for 2-stroke diesel engine

6. 

(*f*) CO_2 in exhaust gases *vs.* air fuel ratio.

1.12. Match parts A and B regarding automobiles.

A	B
1. A __________ device acting as a friction clutch, brings the gears to be meshed approximately to the correct speed just before meshing	(*a*) square of speed
2. The __________ is a unit attached to the ring gear which equalises the traction of both wheels and permits one wheel to turn faster than the other, as needed on curves.	(*b*) air
3. __________ is the angle, in side elevation, between the steering axis and the vertical	(*c*) 2.67
4. __________ is the inclination of the wheel plane from the vertical.	(*d*) differential
5. The maximum retarding force which can be applied to a vehicle through its wheels is limited by the friction between tyres and the __________	(*e*) tyre resistance
6. Stopping distance of vehicles is proportional to __________	(*f*) nine

7. The traction required for steady motion of a vehicle on a level road is the sum of air resistance and __________	(*g*) caster
8. __________ resistance is proportional to square of speed of the vehicle.	(*h*) road
9. Tyre resistance is about __________ times the rolling resistance for rail cars on steel rails.	(*i*) camber
10. Average gear ratio for first gear is __________	(*j*) synchro-mesh

1.13. Match the two parts in connection with nuclear physics.

A	B
1. A reaction caused by changes in the electron structure surrounding the nucleus.	(*a*) neutron diffractrometry.
2. A reaction that occurs when the particles making up the nucleus of an atom are rearranged.	(*b*) alpha particle
3. A technique used to determine the molecular and crystalline structure of materials.	(*c*) beta decay
4. A particle whose mass is the same as that of an electron and whose charge is equal in magnitude but opposite in sign.	(*d*) isotopes.
5. When an unstable nucleus undergoes atomic disintegration by emitting α, β, γ or X-ray electromagnetic radiation	(*e*) fission
6. The process of division of an atomic nucleus into parts of comparable mass either spontaneously or by induced means.	(*f*) binding energy
7. __________ involves emission of an electron from the nucleus of an atom.	(*g*) chemical reaction.
8. Elements which have identical chemical characteristics but different atomic weights.	(*h*) positron
9. Work required to disintegrate an atom completely into total protons and neutrons.	(*i*) radioactivity
10. A particle identical with the nucleus of a helium atom.	(*j*) nuclear reaction

1.14. Match parts A and B in connection with materials used in nuclear power plants.

A	B
1. Nuclear power is the energy derived from the fission of the nuclei of heavy elements, such as __________	(*a*) CO_2
2. Nuclear power is also the energy derived from fusion of the nuclei of light elements, such as __________	(*b*) sodium
3. __________ is the coolant usually used in natural-uranium reactors.	(*c*) hafnium
4. Control rods, burnable neutron absorbers, and soluble __________ in the coolant are used to control excess reactivity.	(*d*) thorium

5. __________ is the most widely used moderator.	(*e*) plutonium
6. Materials used for control purposes must have high cross section for absorption of neutrons, low mass, etc. Some examples are boron, cadmium, and __________	(*f*) fertile
7. Choice of a liquid-metal coolant is based mainly on nuclear properties and on the engineering difficulties associated with melting temperatures and corrosion effects. __________ is preferred because of its availability, good nuclear properties, and the short half life of its induced radioactivity.	(*g*) tritium
8. The fissionable materials are those isotopes of uranium and __________ which fission upon interaction with thermal neutrons.	(*h*) depleted uranium
9. The __________ materials are those isotopes of uranium and plutonium which have even atomic weights.	(*i*) graphite
10. To protect reactor operating personnel against damaging biological effects of neutrons and gamma rays, shielding with materials like lead, tungsten, __________ is required around a nuclear reactor.	(*j*) boron

1.15. Match the two parts relating of nuclear plants

A	B
1. Extensive water-purification equipment is required to remove corrosion products and other impurities from the feed water before introduction into the reactor.	(*a*) fast breeder reactors
2. __________ offer low fuel and operating costs because of their ability to utilise natural uranium as fuel.	(*b*) water cooled reactors
3. __________ operate at extremely high power densities as they are unmoderated and are liquid metal cooled.	(*c*) breeder reactor
4. The main objective of reactor design is to achieve __________ during reactor operation.	(*d*) boiling water reactor
5. A nuclear reactor that produces more fissionable material than it consumes, regardless of the type of fuel used.	(*e*) pressurised water reactor.
6. If the ratio of a number of fissile nuclides produced by the capture of neutrons by the fertile nuclides to the number of fissile nuclides consumed is greater than unity, it is called the __________ ratio.	(*f*) gas cooled reactors
7. For utilisation of __________ as a fuel, D_2O is substituted for H_2O as the coolant-moderator.	(*g*) light water reactor
8. It uses water as a coolant and moderator.	(*h*) natural uranium
9. The __________ require slightly enriched fuel.	(*i*) neutron balance

A	B
10. The ________ presently represent the greatest fraction of installed reactors.	(*j*) breeding

1.16. Match parts A and B relating to coals.

A	B
1. Coals are classified according to __________, *i.e.* according to their degree of metamorphism, or progressive alteration in the natural series from lignite to anthracite	(*a*) proximate analysis
2. Hard and compact coal having shiny black colour, with a generally conchoidal fracture	(*b*) coke
3. Brown to black in colour and have a bed moisture content of 30 to 45% with a resulting lower heating value than higher-rank coals.	(*c*) caking
4. The simplest means for determining the distribution of products obtained during heating.	(*d*) rank
5. Heat produced by complete combustion of a unit quantity of coal, at constant volume, under standard conditions, as in an oxygen-bomb calorimeter.	(*e*) coking coals.
6. The fusion process in a boiler furnace	(*f*) free swelling index
7. Coals that make good coke, and are suitable for metallurgical purposes.	(*g*) anthracite
8. Infusible, cellular, coherent, solid material obtained from coal, pitch, petroleum residues, and from some other carbonaceous materials such as the residue from destructive distillation.	(*h*) volatile matter.
9. An indication of caking characteristics of the coal when burned on fuel beds.	(*i*) gross calorific value
10. Loss in weight, less moisture, obtained by heating the coal for seven minutes in a covered crucible at about 950°C.	(*j*) lignite

1.17. Match parts A and B relating to liquid fuels.

A	B
1. Seldom used as fuel	(*a*) dispersants
2. Engine power output and fuel economy are limited by the __________ characteristics of the fuel.	(*b*) coal tar
3. __________ compounds are used to reduce spark-plug fouling, to modify deposit formation in the combustion chambers, and to eliminate surface-ignition problems	(*c*) anti-knock
4. The combustion characteristics of diesel fuels are expressed in terms of	(*d*) aircraft piston
5. The __________ are added to diesel fuel to prevent agglomeration of gum or sludge deposits so these deposits can pass through filters, injectors, and engine parts without plugging	(*e*) hydrogeneration

6. __________ has an octane number of 99 and is thus blended with gasoline.	(*f*) phosphorous
7. A by-product of the destructive distillation of bituminous coal to produce coke.	(*g*) kerosene
8. __________ is less volatile than gasoline and has a higher flash point to provide greater safety in handling.	(*h*) crude oil
9. Gasolines for __________ engines have fewer low-boiling and fewer high-boiling components	(*i*) ethyl alcohol
10. __________ of gasoline improves octane number, removes sulphur and nitrogen, and increases storage stability.	(*j*) cetane number

1.18. Match parts A and B relating to combustion.

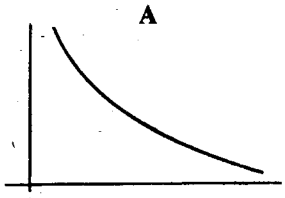
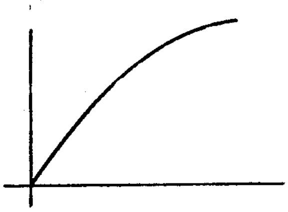
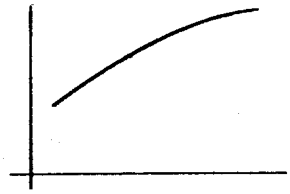
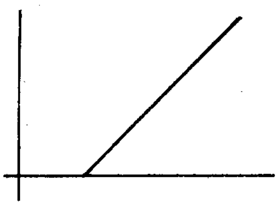
A	B
1. The condition of incomplete combustion is sensed by measuring __________	(*a*) low heat value
2. Heat value with products of combustion cooled to initial condition is called	(*b*) $C \times CO/(CO + CO_2)$
3. When there is contraction of volume due to combustion, then __________	(*c*) change in No. of moles × universal gas constant × temperature of combustion
4. Heat value calculated by assuming no water vapour condensation	(*d*) simple energy balance
5. The maximum temperature that can be obtained by the combustion of any fuel is limited by	(*e*) nitrogen content in the flue gases
6. Loss due to incomplete combustion of carbon in the fuel is proportional to	(*f*) CO in flue gas
7. If the reactants and products of combustion are assumed to be ideal gases, then difference in enthalpies at constant pressure and constant volume is equal to	(*g*) heat at constant pressure is greater than heat at constant volume
8. Excluding the effect of dissociation, the temperature attained at the end of combustion may be calculated by a __________	(*h*) CO_2 in flue gases
9. Good combustion and high efficiency is indicated by high volume of __________	(*i*) the dissociation of the products formed
10. Hydrogen in a fuel increases the __________	(*j*) high heat value.

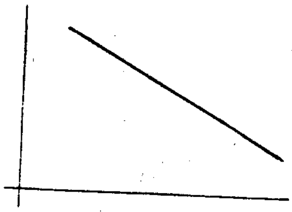
1.19. Match parts A and B regarding steam boilers.

A	B
1. Furnaces usually provided with water-cooled water surfaces to keep the ash relatively dry	(*a*) soot blowers
2. Additives such as dolomite, lime, and magnesia are effective in reducing the __________ of fly ash.	(*b*) stack effect
3. Slow speed mill consisting of a rotating drum with a tumbling charge of steel balls is adaptable to __________	(*c*) 63 tonnes per hour

4. High speed pulverisers are used for all grades of ________	(*d*) sintered strength
5. ________ furnace is designed to burn low-ash-fusion coals and to retain most of the coal ash in the slag.	(*e*) highly abrasive fuels with high silica content
6. Used to maintain boiler efficiency and capacity by the periodic removal of ash and slag from the heat absorbing surfaces.	(*f*) dissolved oxygen
7. Direct-fired pulverisers for large boilers are built for capacities more than ________	(*g*) cyclone
8. ________ is caused by the difference in densities resulting from the difference in the temperature of two vertical columns of gas	(*h*) pulverised coal dry-ash-type furnaces.
9. ________ is the greatest factor in the corrosion of steel surfaces in contact with water.	(*i*) deaerator
10. Dissolved oxygen in feed water is removed by ________	(*j*) bituminous coals

1.20. Match the following curves in part A with description in part B in regard to steam boilers :

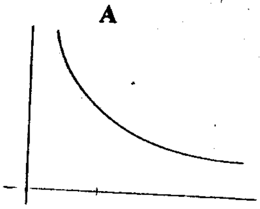
A		B
1.		(*a*) Pulverised capacity index *vs.* grindability index
2.		(*b*) Strength of sintered fly ash *vs.* sintering temperature
3.		(*c*) Minimum metal temperature *vs.* % of sulphur in fuel
4.		(*d*) Heat absorbed in economiser *vs.* heat available in water-cooled pulverised coal-fired furnace.
5.		(*e*) Circulating force in natural circulation boiler *vs.* pressure.

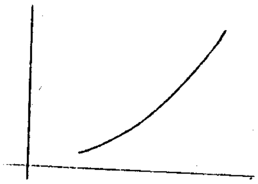
6. 

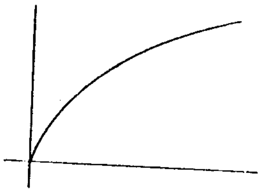
(*f*) Steam temperature *vs.* steam flow in radiant superheater.

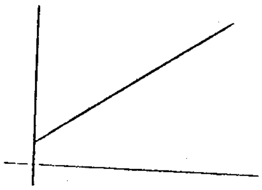
1.21. Match the figures in part A with description in part B

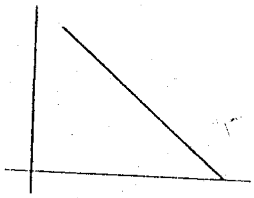
A

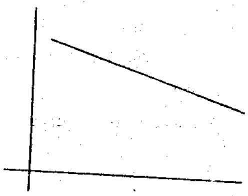
1. 

2. 

3. 

4. 

5. 

6. 

B

(*a*) Mechanical efficiency *vs.* BHP for I.C. engine

(*b*) Steam consumption per H.P. per hour *vs.* horse power in steam engine

(*c*) Total heat *vs.* degree of superheat in steam

(*d*) Steam per kWHr *vs.* output of steam turbine

(*e*) Steam consumption *vs.* horse power in steam engine with constant initial pressure and varying power by altering the cut off

(*f*) Log of pressure *vs.* log of volume for steam

1.22. Match parts A and B in relation to flow through orifices/nozzles.

A	B
1. The smallest cross section of the nozzle is called	(*a*) critical flow pressure
2. The flow through nozzle is assumed to be	(*b*) 0.575
3. Pressure at the throat of a nozzle is called the	(*c*) throat
4. For any nozzle, the ratio of critical to inlet pressure is	(*d*) 0.55
5. Ratio of critical to inlet pressure for gases is	(*e*) isentropic
6. Ratio of critical to inlet pressure for saturated steam is	(*f*) $\dfrac{\text{Outlet area}}{\sqrt{\text{Temperature at inlet}}}$
7. Ratio of critical to inlet pressure for superheated steam is	(*g*) approximately constant
8. When the back pressure is greater than the critical flow pressure, then velocity is proportional to	(*h*) 0.53
9. Mass of air flow through a divergent nozzle at outlet is proportional to	(*i*) supersaturated
10. Steam when expanded rapidly, as in nozzles, becomes.	(*j*) $\sqrt{\text{drop in enthalpy}}$

1.23. Match parts A and B regarding steam engines.

A	B
1. The h.p. developed by steam engine is proportional to mean effective pressure, stroke length and	(*a*) logarithmic
2. Engine economy may be improved by separation of inlet and outlet ports, and using	(*b*) Rankine rate
3. __________ losses can be reduced by using cylinders in series	(*c*) Poppet and piston valve cylinders
4. __________ cycle is the accepted thermodynamic standard for comparing the performance of steam engines	(*d*) throttling
5. Williams line is __________ for a steam engine with fixed cut off and variable initial pressure	(*e*) condensation
6. The expansion phase on pV diagram for steam engines is __________	(*f*) square of diameter
7. Losses in steam engine cylinders are due to incomplete expansion, initial condensation, and __________	(*g*) straight
8. The lowest point of the actual steam-rate curve is usually referred to as the	(*h*) rankine efficiency ratio
9. The ratio of rankine rate to actual rate is called	(*i*) steam jackets
10. With high temperature steam, the cylinder and parts design must allow for free expansion. __________ can easily meet these requirements	(*j*) Rankine

1.24. Match the two parts pertaining to steam turbines.

A	B
1. In __________ stage of steam turbine, the total pressure drop for the stage is taken across the nozzle or stationary element, the flow through the rotor blades, being substantially at constant pressure.	(*a*) turning gear
2. In the __________ stage of steam turbine, the total pressure drop assigned to the stage is divided equally between the stationary blades and the rotor blades.	(*b*) over isochronous
3. Leakage loss of steam between inner circumference of stationary element and rotor is minimised by maintaining minimum practical clearance and by use of __________ packings.	(*c*) aspect ratio
4. The presence of __________ in the steam causes extra losses on account of effect of supersaturation, friction, and exerting a barking effect.	(*d*) back pressure
5. __________ are generally used to keep the rotor of steam turbine turning at low speed to maintain uniform temperature when the turbine is shut down.	(*e*) higher
6. In __________ turbines, the exhaust steam is employed for some heating process.	(*f*) reaction
7. The overspeed governor is of __________ type, arranged to trip the quick closing value to shut off the steam supply to turbine.	(*g*) over speed
8. Speed-control governing system is designed so that even on load throw off, the __________ governor does not come into action	(*h*) labyrinth
9. Stages with longer blade are __________ in efficiency compared to stages with short blade length.	(*i*) impulse
10. Blade length / steam passage width	(*j*) moisture

1.25. Match the two parts for condensers

A	B
1. The purpose of surface condenser in power plant is to create vacuum for improvement of plant heat rate, condense exhaust steam, and to __________	(*a*) hydrazine
2. To remove the last traces of oxygen from the condensate, an ammonia compound such as __________ is normally added.	(*b*) air cooled
3. Condenser water boxes are generally made with curved surfaces because of the inherent strength of cylindrical surfaces as compared to __________	(*c*) rectangular
4. A big factor in condenser performance is __________	(*d*) direct contact

5. For small units, the condenser is supported on __________ and rigidly connected to the turbine.	(*e*) deaerate the condensate
6. Large condensers are __________ for better utilisation of space.	(*f*) jet
7. Where adequate water is not available and to minimise the number of pieces of equipment, _______ condenser is used.	(*g*) flat plates
8. When condensate recovery is not a factor, ________ condensers are effective.	(*h*) springs
9. The __________ condenser utilises the aspirating effect of a jet for the entrainment of noncondensables and the consequent elimination of a separate air pump.	(*i*) non condensable gases and air
10. The steam jet air ejector is used to remove __________ from condensers.	(*j*) tube cleanliness

1.26. Match parts A and B in connection with cooling towers.

A	B
1. Cooling water dissipates heat by the ________ of some of the water sprayed into the air circulated through the water	(*a*) Cooling range
2. The difference in temperature between the cold water leaving the tower and the ambient wet bulb	(*b*) hyperbolic
3. Difference in temperature between the hot water entering and the cold water leaving the tower	(*c*) make up
4. Water lost as mist or droplets entrained by the circulating air and discharged to the atmosphere	(*d*) evaporation
5. Water required to replace total losses by evaporation, drift, blow down, and small leaks.	(*e*) mechanical forced draft
6. __________ tower utilises the chimney effect for natural circulation.	(*f*) cross flow
7. In __________ design, air is introduced beneath the cell fill.	(*g*) induced draft
8. In __________ design, air is introduced at the sides of the fill.	(*h*) counter flow
9. In __________ tower, the fan is mounted on the top of the cell.	(*i*) drift
10. In _________ tower, fans are conveniently located at ground level for inspection and maintenance.	(*j*) approach.

1.27. Match the two parts for compressors.

A	B
1. In case of air compressors, the free air, or ambient, capacity is less than the piston displacement by the __________	(*a*) specific speed
2. In multistage compressors, the diameter of a secondary cylinder can be estimated by dividing the preceding cylinder diameter by ______	(*b*) atu

3. The ________ compressor is used for handling highly saturated vapours, wet vacuums, corrosive and exhothermic gases.	(c) variable speed drivers
4. The helical-screw rotary compressor has a relatively high efficiency at low ___________	(d) 2.7
5. Control of volume flow of compressors is possible by _________	(e) axial
6. The wear pattern of horizontal compressors takes the form of ______	(f) volumetric efficiency
7. The ratio of compression for most optimum conditions is taken as _______	(g) 8
8. The term ______ refers to the gauge pressure in excess of ambient in kg/cm^2.	(h) rotary liquid ring
9. For maximum volumes, the steady flow ____ compressor is used.	(i) 1.41
10. High pressure cylinders smaller than 0.25 m usually have a clearance less than _____% so as to increase the volumetric efficiency.	(j) hourglass

1.28. Match parts A and B regarding gas turbines.

A	B
1. Typically about two thirds of the gas turbine power is used to drive the _________	(a) Output of a given size of gas turbine
2. Gas turbines operate on Brayton cycle. The thermal efficiency of this cycle depends mainly on _________	(b) compressor
3. _________ units can be arranged for improved part-load thermal efficiency	(c) generate steam
4. The _________ engine is a development of the simple jet engine in which a large-diameter compressor stage is added to pump additional air for propulsion.	(d) efficiency
5. Methods of avoiding compressor instability (surge region), during starting and low load and low speed operation, are interstage bleed, discharge bleed. and _________	(e) fan
6. _________ compressors are used on all large gas turbines because of their high efficiency and capacity.	(f) closed
7. The advantage of _________ type gas turbine is that high working fluid density reduces the size of the compressor and turbine.	(g) pressure ratio.
8. In the combined cycle, the hot turbine exhaust gases are used to _________	(h) controllable angle stator vanes
9. The addition of regenerator to recover heat from the turbine exhaust results in increase of the _________	(i) multiple shaft

10. The additions of intercooling in the compressor and reheat of the working fluid during expansion result in increase of the __________	(*j*) axial flow

1.29. Match parts A and B regarding basic principles of measurements

A	B
1. A device for determining the value of magnitude of a quantity or variable	(*a*) accuracy
2. Determining moisture in steam by measuring the temperature in a throttling calorimeter	(*b*) sensitivity
3. The closeness with which the readings of an instrument approach the true value of the variable being measured	(*c*) sensing element
4. The reproducibility of the measurements	(*d*) indirect measurement
5. The ratio of output signal or response of the instrument to the change in input or measured variable	(*e*) dynamic
6. The smallest change in measured value to which the instrument will respond	(*f*) systematic
7. The part that responds directly to the measured quantity, producing a related motion, pressure or electrical signal	(*g*) precision
8. The errors due to assignable causes	(*h*) random
9. Errors caused by the instrument not responding fast enough to follow the changes in measured variable	(*i*) instrument
10. Errors due to causes which can't be directly established	(*j*) resolution

1.30. Match parts A and B in regard to measurement of physical and chemical properties :

A	B
1. Measurement of colour by analysing the colour spectrum	(*a*) profilometer
2. An instrument used to measure the surface characteristics	(*b*) psychrometer
3. A device for measuring transparency of non-opaque liquids and solids	(*c*) orsat apparatus
4. A very powerful instrument for analysis of complex mixtures	(*d*) dewpoint meter
5. Instrument based on the cooling effect of water evaporating into the air stream	(*e*) zirconia sensor
6. Measures the change in length of such humidity sensitive elements as hair and wood	(*f*) throttling calorimeter
7. Measures the temperature at which warer just starts to condense out of the air	(*g*) spectro- photometer
8. Used to determine the moisture in steam	(*h*) hygrometer
9. Used for chemical analysis of flue gases	(*i*) photometer
10. Used to measure oxygen content in the flue gases	(*j*) spectroscopic measurement

1.31. Match parts A and B in regard to mixtures of air and water vapour.

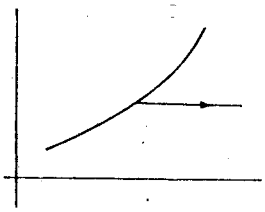
A	B
1. Mixture of air and water vapour	(*a*) dry bulb temperature
2. Sum of vapour pressure and air pressure	(*b*) saturated atmosphere
3. Temperature of the atmosphere as indicated by an ordinary thermometer.	(*c*) relative humiditv
4. If the atmosphere is cooled under constant total pressure, the partial pressure remains constant until a temperature is reached at which condensation of vapour begins	(*d*) total pressure or barmoteric pressure
5. If a thermometer bulb is covered with absorbent material (such as wet cotton with distilled water) and exposed to atmosphere, evaporation will cool the thermometer bulb to __________	(*e*) hygrometer
6. Wet bulb temperature, dry bulb temperature and dew point are identical for	(*f*) atmosphere
7. The ratio of the actual vapour pressure to the pressure of saturated vapour at the prevailing dry bulb temperature	(*g*) specific humidity or humidity ratio
8. Mass of water vapour in mols per one mol of air.	(*h*) wet bulb temperature
9. Mass of water vapour per unit mass of air	(*i*) dew point
10. Relative humidity is measured by	(*j*) molal humidity

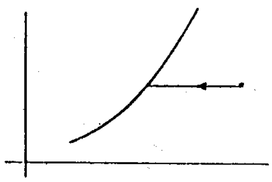
1.32. Match parts A and B relating to air conditioning.

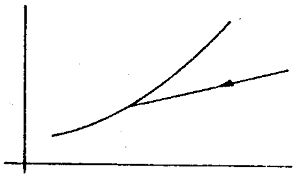
A	B
1. A disadvantage of psychrometric charts is	(*a*) saturation curve
2. The ordinate of psychrometric chart is specific humidity. Other parameter it shows is	(*b*) Heating and cooling above the dew point
3. The specific humidity and vapour pressure for a mixture of air and saturated vapour on psychorometric chart are given by	(*c*) adiabatic saturation (humidification)
4. A process that alters the temperature and specific humidity of the atmosphere	(*d*) correction to other barometric pressures is not easy
5. A process which entails no condensation of vapour	(*e*) cooling below dew point
6. A process that entails condensation of vapour	(*f*) vapour pressure
7. A process accomplished in a surface cooler in which air passes over tubes cooled by refrigerant	(*g*) evaporative condenser
8. A process conducted in a spray chamber through which atmosphere flows	(*h*) cooling tower
9. A chamber in which outdoor atmosphere flows through a spray of entering hot water	(*i*) dehumidification
10. The vapour is condensed within tubes that are cooled by the evaporation of water flowing over the outside of the tubes ; the water evaporates into the atmosphere	(*j*) air conditioning

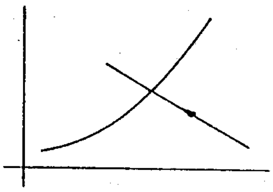
1.33. Match figure in part A with description in part B regarding various processes on psychrometric charts

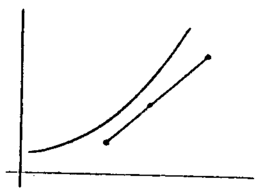
A

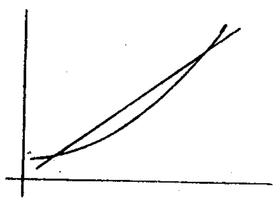
1. 

2. 

3. 

4. 

5. 

6. 

B

(*a*) Mixing two atmospheres (final point above the saturation curve)

(*b*) Cooling and dehumidifying

(*c*) dehumidification

(*d*) Mixing two atmospheres (final point below the saturation curve)

(*e*) evaporative cooling (adiabatic saturation)

(*f*) Heating above the dew point.

1.34. Match parts A and B in relation to fluid properties and fluid statics

1. A substance unable to resist even the slightest amount of shear without flowing	(*a*) Bulk modulus of elasticity
2. A real fluid (having internal friction) in which the rate of deformation is directly proportional to the applied shear stress	(*b*) surface tension

3. Ratio of pressure stress to the volumetric strain — (*c*) fluid
4. Resistance of a fluid to shear motion — (*d*) barometer
5. Ratio of the shearing stress to the rate of deformation — (*e*) viscosity
6. Ratio of dynamic viscosity and density — (*f*) Pascal's principle
7. Work done in extending the surface of a liquid one unit of area — (*g*) dynamic viscosity
8. A device to sense absolute pressure — (*h*) manometer
9. A device to sense differential pressure — (*i*) kinematic viscosity
10. Pressure in a static fluid is the same in all directions — (*j*) Newtonian fluid

1.35. Match parts A and B regard to Mechanics of fluids.

A	B
1. The centre of buoyancy (c.b.) and the centre of gravity (c.g.) lies on the same vertical line and the c.b. must be located above the c.g	(*a*) floating bodies
2. The c.b. and c.g must lie on the same vertical line but the c.b. may be below the c.g.	(*b*) kinematic
3. The line which gives the direction of the velocity of a fluid particle at each point in the flow stream.	(*c*) critical zone
4. __________ similarity exists between model and prototype when their streamlines are geometrically similar	(*d*) hyperbolic
5. The Reynolds number range between 2000 and 4000 is called __________	(*e*) nappe
6. A trapezoidal notch designed with end slopes one horizontal to four vertical	(*f*) parabolic
7. A weir designed to give a constant coefficient of discharge	(*g*) streamline
8. A weir designed to give a linear relationship of head to flow	(*h*) pitot tube
9. The sheet of liquid flowing over the weir crest	(*i*) Cipolletti
10. A device shaped in such a manner that it senses stagnation pressure	(*j*) completely submerged bodies

1.36. Match parts A and B for the standard numbers encountered in mechanics of fluids.

A *Force Ratio*	B *Name*
1. $\frac{\text{Inertia}}{\text{Viscous}}$	(*a*) Euler
2. $\frac{\text{Inertia}}{\text{Gravity}}$	(*b*) Cauchy
3. $\frac{\text{Inertia}}{\text{Pressure}}$	(*c*) Froude
4. $\frac{\text{Inertia}}{\text{Centrifugal}}$	(*d*) Strouhal

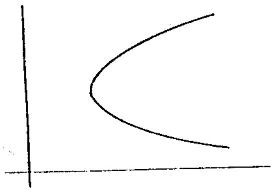
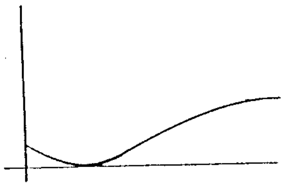
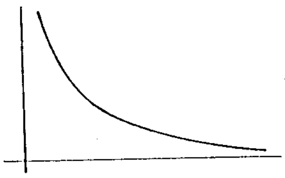
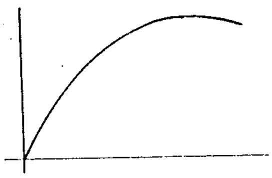
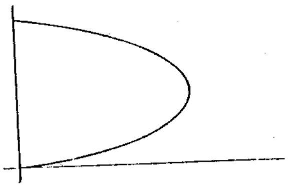
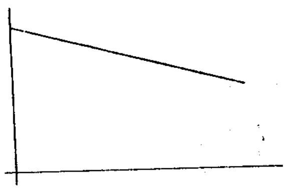
5. $\dfrac{\text{Inertia}}{\text{Elastic}}$ (*e*) Weber

6. $\sqrt{\dfrac{\text{Inertia}}{\text{Elastic}}}$ (*f*) Reynold

7. $\dfrac{\text{Inertia}}{\text{Surface Tension}}$ (*g*) Mach

8. $\dfrac{\text{Inertia}}{\text{Vibration}}$ (*h*) Pressure coefficient

1.37. Match the various curves in Part A with descriptions provided in Part B, in connection with fluid dynamics.

A		B
1.		(*a*) Capillarity in circular tube - Diameter of tube *vs.* capillary rise
2.		(*b*) Hydraulic grade line
3.		(*c*) velocity profile in pipe for laminar flow
4.		(*d*) channel depth *vs.* specific energy
5.		(*e*) deformation characteristic of non- newtonian fluid.
6.		(*f*) relative pressure changes due to flow through an orifice.