

According to Prandtl $\tau = \rho l^2 \left(\frac{dv}{dy} \right)^2$

(l = mixing length and is function of y)

According to Karman,

$$\tau = \tau_0 \left(1 - \frac{y}{r} \right) = \rho k^2 \frac{(dv/dy)^4}{(d^2v/dy^2)^2}$$

where $k \approx 0.4$.

Q. 515. How much shearing stress occurs at a pipe wall and what is the shear velocity of friction velocity ?

Ans. Shearing stress at pipe wall

$$\tau_0 = f \rho V^2 / 8$$

(f = dimensionless frictional factor)

Shear variation at a cross section is linear and $\tau = \left(\frac{p_1 - p_2}{2L} \right) r$ (r = pipe radius).

The term $\sqrt{\tau_0/\rho}$ is called shear velocity of friction velocity = $V \sqrt{f/8}$.

Q. 516. Explain velocity distribution for laminar and turbulent flows.

Ans. In case of laminar flow, the velocity distribution follows a parabolic law of variation. The maximum velocity at centre of pipe is twice the average velocity. For turbulent flow, more uniform velocity distribution results.

Q. 517. In which type of flow the stream lines, streak lines and path lines are identical ?

Ans. In steady flow.

Q. 518. How true kinetic energy can be determined ?

Ans. In general, the velocity distribution across cross section of pipe is not uniform. In such cases the true kinetic energy can be found by integrating the differential kinetic energies from streamline to streamline. The kinetic-energy correction factor (which may vary from 1.02 to 1.15 for turbulent flow and 2.0 for laminar flow)

$$= \frac{1}{A} \int_A \left(\frac{u}{V} \right)^3 dA$$

(u = velocity at any point in the cross section,

V = average velocity in the cross section and

A = area of the cross section).

Q. 519. What are equipotential lines ?

Ans. These are normal to the streamlines at each intersection. Equipotential lines can be defined by $\phi(x, y) = a$ constant. Then for equipotential lines

$$u = \text{velocity along equipotential line} = - \frac{\partial \phi}{\partial x}$$

$$\text{and } v = \text{velocity along streamline} = - \frac{\partial \phi}{\partial y}$$

$$\text{Also as per Laplace equation } \frac{\partial^2 \phi}{\partial x^2} + \frac{\partial^2 \phi}{\partial y^2} = 0$$

and according to continuity equation $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$.

Q. 520. What do you understand by Laplace equation and continuity equation ?

Laplace equation : If ψ is the flow rate of a streamline and is constant, then according to Laplace equation

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0.$$

Continuity Equation : If ψ is the flow rate of a streamline and is constant, then

$$v = \text{velocity along streamline} = -\frac{\partial \psi}{\partial x}$$

and $u = \text{velocity normal to streamline} = \frac{\partial \psi}{\partial y}$

and as per continuity equation $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$.

Q. 521. In which type of flow the Navier - Stokes equation is useful ?

Ans. Viscous flow.

Q. 522. Explain the difference between energy line and hydraulic grade line ?

Ans. The energy line is a graphical representation of the energy at each section.

Hydraulic grade line lies below the energy line by an amount equal to the velocity head at the section.

Q. 523. What is the characteristic of equipotential line ?

Ans. It has no velocity component tangent to it.

Q. 524. What is Hagen - Poiseuille law of laminar flow ?

Ans. According to this formula, the total discharge through a pipe = $\frac{\pi D^4 (P_1 - P_2)}{128 \mu L}$

$P_1 - P_2 =$ difference in pressure between the two ends.

Q. 525. What is hydraulically rough pipe ?

Ans. When Reynolds number is very small, friction factor f becomes independent of the Reynolds number and depends only on the relative roughness height. Such a pipe behaves as hydraulically rough pipe.

Q. 526. What is Von Karman formula ?

Ans. For hydraulically rough pipe, friction factor f is

$$\frac{1}{\sqrt{f}} = 2 \log \left(3.7 \frac{D}{e} \right)$$

(where $e/D =$ roughness height of pipe).

Q. 527. What is hydraulically smooth pipe flow and write down value of friction factor for this flow ?

Ans. A pipe is hydraulically smooth if the average roughness height e is less than the thickness of the laminar sublayer. For this, the friction factor ' f ' is not affected by the surface roughness of the pipe.

The Von Karman formula for hydraulically smooth pipe, friction factor ' f ' is

$$\frac{1}{\sqrt{f}} = 2 \log \left(\frac{\text{Re} \sqrt{f}}{2.51} \right).$$

Q. 528. Which equation is satisfied by ideal or real, laminar or turbulent flow ?

Ans. Continuity equation.

Q. 529. Explain transition from laminar to turbulent flow in pipe.

Ans. It depends not only on velocity, but also on the pipe diameter and the viscosity of the fluid (i.e. Reynolds number, R_e).

Laminar flow is independent of surface roughness of the pipe. Friction factor ' f ' for laminar flow is $64/R_e$.

For $Re \geq 2000$, the flow becomes turbulent and value of ' f ' depends not only on R_e but also on the relative roughness height e/D (e = measure of the average roughness height of the pipe wall and D the pipe diameter). For fully developed turbulent flow in pipe, value of ' f ' depends solely on e/D and not on R_e .

Q. 530. What is loss in head in sudden contraction, enlargement and bend ?

Ans. Loss of head in sudden contraction : It may be represented as $K_e \frac{V^2}{2g}$ (V = velocity in downstream pipe) and K_e = coefficient of sudden contraction and varies from 0.49 to 0.03 depending on ratio of D_2/D_1 and velocity in smaller pipe.

Loss of head due to sudden enlargement :

$$\text{Head loss} = \frac{V_1^2 - V_2^2}{2g}$$

Loss of head in bend : It is dependent on the ratio of radius of curvature of the bend to the diameter of pipe.

Q. 531. How much loss of head occur due to sudden enlargement in a pipe ?

Ans. $(V_1 - V_2)^2/2g$.

Q. 532. What is critical velocity ?

Ans. It is the velocity below which all turbulence is damped out by the viscosity of the fluid.

Q. 533. What is laminar flow ?

Ans. In laminar flow the fluid particles move along straight, parallel paths in layers or laminae. Laminar flow is governed by the law relating shear stress to rate of angular deformation i.e. the product of the viscosity of the fluid and velocity gradient.

Q. 534. How shear forces are incurred in fluid flow ?

Ans. Shear forces between fluid particles and boundary walls and between the fluid particles themselves, result from the viscosity of the real fluid.

Q. 535. In laminar flow, how discharge is related to viscosity ?

Ans. Discharge varies inversely as viscosity.

Q. 536. What is best hydraulic section ?

Ans. Best hydraulic section is one in which for a given cross-section area, the channel section has least wetted perimeter.

Q. 537. What is best hydraulic trapezoidal section ?

Ans. It is a half-hexagon in shape.

Q. 538. What is specific energy in a channel section ?

Ans. It is defined as the energy head measured with respect to the channel bottom at the section. At any section, it is equal to sum of the velocity head and the water depth at the section.

Q. 539. What is critical depth and critical flow ?

Critical depth is the depth, at which the discharge may be delivered through the section at minimum energy.

Critical flow is the flow in open channel corresponding to critical depth.

Q. 540. What causes boundary layer separation ?

Ans. An adverse pressure gradient.

Q. 541. Shape various formulae for pipe flow ?

Ans. C. F. Colebrook formula : When pipe behaves neither smoothly nor completely rough, then friction factor is related as

$$\frac{1}{f} = -2 \log \left(\frac{e}{3.7D} + \frac{2.51}{\text{Re} \sqrt{f}} \right)$$

(e/D = roughness height of pipe)

Hazen-Williams formula : It is used for water flow in larger pipes ($D \geq 5$ cm) within a moderate range of water velocity ($V \leq 3$ m/s)

$$V = 0.85 C_{HW} R_H^{0.63} S^{0.54}$$

(S = slope of the energy gradient line, R_H = hydraulic radius,

C_{HW} = Hazen - William coefficient, (It varies from 110 to 150).

Manning formula : $V = \frac{1}{n} R_H^{2/3} S^{1/2}$, n = Manning's coefficient of roughness.

Q. 542. At what point below free surface in a uniform laminar flow in a channel the point velocity is equal to mean velocity of flow ?

Ans. At 0.577 depth of channel.

Q. 543. What is the value of friction factor for smooth pipe when Reynolds number is approximately = 10^6 ?

Ans. 0.01.

Q. 544. How hydraulic grade line and free surface of open channel flow related ?

Ans. They coincide.

Q. 545. For what purpose hydraulic jump is used ?

Ans. For reducing the energy of flow.

Q. 546. When rapid closure occurs ?

Ans. When the time of closure of a valve (t_c) is smaller than the time required for the wave front to make a round trip along the pipeline and return to the valve site

$$\left(\frac{2L}{c} = \frac{2 \times \text{pipe length}}{\text{speed of wave travel along the pipe}} \right)$$

Q. 547. What is open channel flow ? Explain 4 types of open channel flows.

Ans. Open channel flow has a free water surface which is normally subject to the atmospheric pressure.

Steady open channel flow : In this case the discharge and water depth at any section in the reach do not change with time during the period of interest.

Unsteady open channel flow : In this case the discharge and the water depth at any section in the reach change with time.

Uniform open channel flow : In this case the discharge and the water depth remain the same in energy section in the channel reach. It is mostly steady.

Varied open channel flow : In this case the water depth and/or the discharge change along the length of the channel. It may be steady (such as flow over a spillway crest) or unsteady (as in the case of flood waves or tidal surge).

Q. 548. When does wake occur ?

Ans. It occurs after a separation point.

Q. 549. Define continuity equation.

Ans. According to continuity equation, mass entering = mass rate of storage + mass rate leaving

In differential form, it is written as $\frac{dA}{A} = \frac{dV}{V} - \frac{d\rho}{\rho}$

For compressible fluids, it is written as $\frac{dA}{A} = -\frac{dV}{V} (1 - M^2)$

where $M = \text{Mach number} = \frac{\text{actual velocity}}{\text{speed of sound}}$

Q. 550. What is hydraulic radius ?

Ans. It is the ratio of fluid flow area/shear perimeter.

Q. 551. Define flow work.

Ans. Flow work is the amount of mechanical energy required to push or force a flowing fluid across a section boundary.

Q. 552. What do you understand by dimensional analysis ?

Ans. Dimensional analysis is the mathematics of dimensions and quantities and provides procedural techniques whereby the variables that are assumed to be significant in a problem can be formed into dimensionless parameters, the number of parameters being less than the number of variables.

Q. 553. What is hydraulic depth for open channel flow ?

Ans. It is the ratio of area and the top width of the channel section.

Q. 554. Explain difference between supercritical and subcritical flow ?

Ans. Supercritical flow : The state of rapid and hallow flow through a section of open channel. For this, Froude number > 1 ,

Subcritical flow : The tranquil, high-stage flow. For this, Froude number $\frac{v}{\sqrt{gD}} < 1$

($D = \text{hydraulic depth}$)

Q. 555. What is Froude number ?

Ans. It is the ratio of $\frac{\text{velocity}}{\sqrt{g \times \text{hydraulic depth}}}$

Q. 556. What is hydraulic jump ?

Ans. It is a natural phenomenon in open channel. It is an abrupt reduction in flow velocity by means of a sudden increase of water depth in the down stream direction. Through a hydraulic jump, and high-velocity supercritical flow is changed to a low-velocity subcritical flow.

Q. 557. What is gradually varied flow ?

Ans. The changes in water depth in the open channel take place very gradually with distance. Depending on the channel slope, the surface conditions, the sectional geometry, and the discharge, these may be classified into five categories : - steep channel, critical channel, mild channel, horizontal channel, and adverse channel.

Q. 558. Explain 5 types of channels.

Ans. Steep channel : In this case normal depth < critical depth.

Critical channel : In this case normal depth = critical depth.

Mild channel : In this case, normal depth > critical depth.

Adverse channel : In this case, the slope of channel bed < 0.

Horizontal channel : In this case, the slope of channel bed = 0.

Q. 559. What is head loss in hydraulic jump ?

Ans. If d_1 and d_2 be the initial depth and the sequent depth of a hydraulic jump then head loss

$$= \frac{(d_2 - d_1)^2}{4d_1 d_2}$$

Q. 560. Write equation for gradually varied flow.

Ans. The general differential equation for gradually varied flow is

$$\frac{dd}{dx} = \frac{S_o [1 - (d_n/d)^{10/3}]}{[1 - (d_c/d)^3]}$$

where d = actual water depth of channel at any section of interest.

d_n = normal depth for uniform flow.

d_c = critical depth.

S_o = energy slope = slope of channel bed (in uniform flow).

x = channel distance.

If $\frac{dd}{dx} = 0$, water depth is constant throughout the reach.

If $\frac{dd}{dx} < 0$, the water depth decreases in the direction of flow.

If $\frac{dd}{dx} > 0$, the water depth increases in the direction of flow.

Q. 561. What is similarity between normal shock wave and hydraulic jump ?

Ans. Both are analogous and irreversible.

Q. 562. How much loss of head occurs for laminar flow ?

Ans. Loss of head for laminar flow = $\frac{32 \mu L V}{\rho g d^2}$

(μ = viscosity, L = length, V = average velocity, ρg = unit weight, d = diameter).

Q. 563. What is Darcy-Weisbach formula ?

Ans. It is the basis of evaluating the loss of head flow for fluid flow in pipes and conduits.

Lost head
$$h_L = f \times \frac{L}{d} \times \frac{V^2}{2g}$$

Q. 564. What is relative roughness of pipe ?

Ans. It is the ratio of the size of the surface imperfections to the inside diameter of the pipe.

Q. 565. What is friction factor ?

Ans. For laminar flow in all pipes for all fluids, $f = \frac{64}{\text{Reynold Number}}$

For turbulent flow in smooth and rough pipes, $f = \frac{8 \times \text{shearing stress at pipe wall}}{\text{mass density} \times (\text{average velocity})^2}$

Q. 566. Under what condition the effect of compressibility of fluid can be neglected ?

Ans. When Mach number is less than 0.4.

Q. 567. For which type of flow the velocity distribution in a pipe is parabolic.

Ans. For uniform laminar flow.

Q. 568. What is the relationship between centre line velocity and average velocity for a laminar flow in a pipe ?

Ans. average velocity = 1/2 centre line velocity.

Q. 569. On which factor the friction factor for a smooth pipe in turbulent flow depends ?

Ans. Reynolds number.

Q. 570. What do you understand by pipe branchings ?

Ans. When water is brought by pipes to a junction where more than two pipes meet, then the total amount of water brought by pipes to a junction must always be equal to that carried away from the junction by other pipes, and all pipes that meet at the junction must share the same pressure at the junction.

Q. 571. What is pipe networks and what are the condition for network ?

Ans. Pipe network comprises a number of pipes connected together to form loops and branches.

For a network, (i) at any junction, $\Sigma Q = 0$ and (ii) between any two junctions the total head loss is independent of the path taken.

Q. 572. What is Hardy-Cross Method ?

Ans. It is a commonly used computer program for a pipe network.

Q. 573. Explain water hammer.

Ans. The force resulting from changing the speed of the water mass (say in a pipe due to sudden change of flow rate) may cause a pressure rise in the pipe with a magnitude several times greater than the normal static pressure in the pipe. Pressure head caused by water hammer = $\frac{V}{g} C$ (V = velocity in pipe, C = celerity).

Q. 574. What is Celerity ?

Ans. It is speed of the wave travel along the pipe. Celerity $C = \sqrt{\frac{E_c}{\rho}}$ where E_c is composed of the elasticity of pipe walls and the elasticity of fluid within.

$$\frac{1}{E_c} = \frac{1}{E_b} + \frac{Dk}{E_p t}$$

E_b = modules of elasticity of water

E_p = modules of elasticity of the pipe wall material

ρ = density of water

D = pipe diameter

t = pipe thickness

k = constant depending on the method of pipe line anchoring

value of k	Method of pipe anchoring
$\frac{5}{4} - \epsilon$	pipe free to move longitudinally
$1 - \epsilon^2$	pipes anchored at both ends against longitudinal movement
$1 - 0.5 \epsilon$	pipe with expansion joint
$\epsilon =$ Poisson's ratio of the pipe wall material	
$= 0.25$ for common pipe materials	

Q. 575. Define the terms hydraulic similitude and dimensional analysis.

Ans. Hydraulic similitude is the principle on which the model studies are based.

Dimensional analysis is the analysis of the basic relationship of the various physical quantities involved in the static and dynamic behaviours of water flow in a hydraulic structure.

Q. 576. Explain the difference between geometric similarity, kinematic similarity and dynamic similarity.

Ans. Geometric similarity : It implies similarity of form. The model is a geometric reduction of the prototype and is accomplished by maintaining a fixed ratio for all homologous lengths between the model and the prototype.

Kinematic similarity : It implies similarity in motion. Kinematic similarity between a model and the prototype is attained if the homologous moving particles have the same velocity ratio along geometrically similar paths. It involves the scale of time as well as length.

Dynamic similarity : It implies similarity in forces involved in motion.

Q. 577. Define Reynolds law ?

Ans. When the inertial force and the viscous force are considered to be the only forces governing the motion of the water, the Reynolds number of the model and the prototype must be kept at the same value.

Q. 578. State the Froude number law and Weber number law.

Ans. Froude Number Law : When the inertial force and the gravity force are considered to be the only forces that dominate the fluid motions, the Froude number

$\left(\frac{\text{Velocity}}{\sqrt{\text{gravity acceleration} \times \text{length}}} \right)$ of the model and the prototype should be kept at the same value.

Weber Number Law : Weber number

$\left(\frac{\text{density} \times \text{Velocity} \times \text{Length}}{\text{surface tension}} \right)$ must be kept at the same value in the model and in the prototype for studying phenomenon governed by surface tension force.

Q. 579. On what factor the friction factor for a rough pipe in turbulent flow depends ?

Ans. Relative roughness.

Q. 580. What is unit power of a turbine ?

Ans. $P/H^{3/2}$.

Q. 581. How cavitation causes damage ?

Ans. In a closed system (pipelines, or pumps), water vaporises rapidly in regions where the pressure drops below the vapour pressure. This phenomenon is called cavitation. The vapour bubbles formed in cavitation usually collapse in a violent manner, which may cause considerable damage to the system.

Q. 582. What are two essential conditions for homologous turbine units ?

Ans. $P/QH = \text{constant}$ and $H/N^2 D^2 = \text{constant}$.

Q. 583. How does cavitation manifest itself in a centrifugal pump ?

Ans. Usual symptoms of cavitation of pump are noise, vibration, a drop in head and capacity with a decrease in efficiency, accompanied by pitting and corrosion of the impeller vanes.

Q. 584. What happens if centrifugal pump is operated at excessive speeds ?

Ans. When a pump is operated at excessive speeds, the differential pressure developed increases and causes a powerful pulsating vacuum on the underside of the blade tips and each particle of water is pulled away from the blade, taking away with it a small particle of metal, producing pitting/grooved effect. Repeated erosive action results in complete honey combing and total destruction of blade, with resultant loss in pump performance.

Q. 585. On what parameters the head developed by a centrifugal pump depends ?

Ans. It depends upon the impeller diameter and its rotative speed.

Q. 586. What are the laws of affinity for centrifugal fans/pumps/blowers.

Ans. Laws of affinity state that flow of centrifugal machine varies directly as speed, pressure as square of speed, and power as cube of speed. For a particular pump, at constant speed, capacity varies directly as impeller diameter D , head $\propto D^2$ and power $\propto D^3$.

Q. 587. What is the disadvantage of centrifugal pump having very low specific speed ?

Ans. For a centrifugal pump having very low specific speed, the impeller diameter is large and narrow having excessively high disc friction and excessive hydraulic losses.

Q. 588. On what factors the efficiency of pump depends ?

Ans. Efficiency of a pump (centrifugal) depends on the size, speed, and proportions of the impeller and casing.

Q. 589. On what factors the cavitation in centrifugal pumps is dependent ?

Ans. Cavitation in centrifugal pumps depends on the velocity of water entering the impeller and on the relative velocity of the impeller blades where the water is picked up.

Q. 590. What are the losses in a centrifugal pump ?

Ans. The losses in a centrifugal pump are : Friction losses due to eddies in flow, leakage, friction loss due to rotation of impeller in chamber of water, gland and bearing power losses.

Q. 591. What should be done to avoid cavitation in pumps ?

Ans. In order to avoid cavitation, the suction lift and the operating speed must be carefully chosen.

Q. 592. What will happen if speed of reciprocating pump is increased ?

Ans. If speed of a reciprocating pump is increased beyond a limit, then atmospheric pressure would be insufficient to force water into the pump at the same speed as the piston. This would cause a break in the continuity of the water in suction pipe (cavitation) and give rise to vibration, noise, and chemical attack by any dissolved gases which may be released from the water owing to the high vacuum and the breaking of the water column.

Q. 593. What is the order of efficiency of centrifugal and reciprocating pumps ?

Ans. The efficiency of centrifugal pump is of the order of 45% whereas of reciprocating pump is around 80%.

Q. 594. Enumerate the advantages of (a) centrifugal pumps, (b) reciprocating pumps.

Ans. (a) The advantages of centrifugal pump are

- (i) Higher speed resulting in lower size and cost
- (ii) Continuous delivery free from pressure fluctuations.
- (iii) It can operate on minimum flow without exceeding a predetermined pressure, maximum flow without exceeding a predetermined demand, be designed to meet several duties.
- (iv) Absence of vibration and simpler foundation.

- (b) The advantages of reciprocating pumps are
- (i) Higher efficiency than centrifugal pumps.
 - (ii) Applicable to variable pressures without adjustment of speed.
 - (iii) Self-priming.
 - (iv) Capable of utilising kinetic energy of rotation to give peak pressures.
 - (v) Confined to low quantity and high pressure.

Q. 595. How the positive displacement is obtained in rotary pumps ?

Ans. Positive displacement in rotary pumps is achieved in two ways :

- (i) A rotor carries radially adjustable vanes, the outer tips of which are constrained by a circular casing, whose centre is remote from that of the rotor.
- (ii) Various combinations of gears, lobes, helices, etc., within a casing arranged so that lobes or teeth attached to each rotor pass in sequence through the same pumping space.

Q. 596. (a) How the quantity, head, and power vary as speed of centrifugal pump is increased ?

(b) How the quantity, head and power vary as size of pump is increased, keeping speed constant ?

Ans. (a) Quantity \propto speed, head \propto speed², power \propto speed³.

(b) Quantity \propto size³, head \propto size², power \propto size⁵.

Q. 597. Under what condition the flow and power of pump vary as square of the size ?

Ans. The flow and power vary as size² when the geometric size changes as inverse of change of speed.

Q. 598. How the incidence of cavitation detected ?

Ans. The incidence of cavitation is detected by the following in order of appearance.

- (i) stroboscopic observation of bubble appearance and size
- (ii) sensitive acoustic tests of cavitation noise
- (iii) reduction of efficiency and/or head of 3%.

Q. 599. How cavitation erosion is assessed ?

Ans. Cavitation erosion is assessed by depth of attack or weight of metal removed.

Q. 600. At which temperature the cavitation erosion is negligible and why ?

Ans. Cavitation erosion is negligible at above 300° C because the water and steam have same densities at critical temperature of 374°C and thus there is no volume change or bubble collapse in the vicinity of this range.

Q. 601. What is the importance of the ratio of diameter of the throat to the diameter of the impeller of pump and how it is related with flow, head, and speed.

Ans. The ratio of the diameter of throat to the diameter of the impeller of pump is proportional to $\frac{\text{rev/min} \times \sqrt{\text{flow}}}{\text{Head}^{3/4}}$.

This ratio is low for pump handling small quantity and high head, *i.e.* large impeller diameter with narrow outlet is required to give small flow areas and small quantity. Large impeller will have large disc friction and thus efficiency will be low.

This ratio is high for pump handling large quantity and a low head. It has wide impeller and a relatively small diameter. The efficiency is low due to lack of guidance in the short impeller passages. The optimum efficiency is obtained for in between conditions.

Q. 602. The type number of a pump is an expression to define the shape of the pump. What is type number ?

$$\text{Ans. Type number} = \frac{\text{rev/min} \times \sqrt{\text{litres/sec}}}{\text{head}^{3/4}}$$

Q. 603. On what factors the efficiency of a centrifugal pump depends ?

Ans. The efficiency of a centrifugal pump depends on size, speed and type number.

Q. 604. How the efficiency of a pump varies with increase in type number, and size.

Ans. The efficiency of a pump is low for low and high type numbers and is maximum in the centre.

The efficiency improves with increase in size and then drops beyond an optimum value. The improvement in efficiency due to increase in size is because head \propto velocity², and losses are \propto Re^{1.7} or 1.8.

Q. 605. A 200 mm impeller of centrifugal pump develops discharge head of 2 kg/cm². It discharge head is required as 8 kg/cm², what should be diameter of impeller.

Ans. 400 mm.

Q. 606. Why thin-plate orifice is frequently recommended for flow measurement in most of the cases ?

Ans. It is recommended because of its high accuracy, low cost, and extreme flexibility.

Q. 607. How the water flow from a hydrant in a city water system be measured ?

Ans. It can be measured by allowing the flow of water from a hydrant and noting down the horizontal distance (x) where jet strikes the ground and the vertical distance (y) of outlet from ground. Then flow = area of hydrant $\times \sqrt{\frac{x^2 g}{2y}}$.

Q. 608. For the same size, length and condition of pipe, how the friction head loss changes if pipe size is varied.

Ans. Under same flow conditions the friction head loss increases as the size change to the 4.8th power.

Q. 609. How does the capacity changes in pipe flow with increase in pipe diameter if head is constant ?

Ans. At constant head, capacity is proportional to $d^{2.5}$.

Q. 610. How does the head change in pipe flow with change in diameter, if capacity is constant.

Ans. At constant capacity, head is proportional to $\left(\frac{1}{d}\right)^5$.

Q. 611. How head varies in pipe flow with change in flow, if pipe diameter is same.

Ans. At constant diameter, head is proportional to (flow)².

Q. 612. What is Euler's equation of motion ?

Ans. For a fluid element of length ds under the action of gravity and of pressure in the direction of flow, at angle θ to horizontal,

$$\frac{1}{2} \frac{d(v^2)}{ds} - g \cos \theta + \frac{1}{\rho} \frac{dp}{ds} = 0$$

Q. 613. Define the term contraction coefficient.

Ans. The ratio of area of jet (contracted) and the cross section of the orifice.

Q. 614. What is stagnation point and stagnation pressure ?

Ans. Point *S* in Fig. on right is stagnation point.

The pressure at point *S* is higher than other points in the free stream by $\frac{v^2 \rho}{2}$ which is known as stagnation pressure.

Q. 615. What for Ser's disk is used ?

Ans. Fig. on right shows Ser's disk used to measure the pressure inside the pipe in free flow. A small hole in the centre of this disk is connected to a manometer by means of a thin pipe.

Q. 616. How does capacity change in pipe flow with change in head, if diameter is constant ?

Ans. At constant diameter, capacity is proportional to (head)^{1/2}.

Q. 617. If 2 jets are used in a Pelton wheel, its specific speed will increase by a factor of ?

Ans. $\sqrt{2}$, because power is directly proportional to no. of jets and specific speed is proportional to square root of power.

Q. 618. How is a Pelton turbine braked ?

Ans. A pelton wheel is braked by a nozzle directing a jet on the back of the buckets.

Q. 619. Why bucket speed of pelton wheel maintained equal to half the velocity of jet ?

Ans. Because η of Pelton wheel is maximum under such a condition.

Q. 620. What is dam and arch dam ?

Ans. A dam is a barrier structure placed across a watercourse to store or slow the normal water flow.

Arch dam is normally built on solid rock foundations that provide resistance to the load by arch actions.

Q. 621. What is the difference between weir, submerged weir.

Ans. Any obstruction of a streamflow over which water flows is weir. When the downstream water level rises over the weir crest, it is called submerged weir.

Q. 622. What is the difference between spillway and siphon spillway ?

Spillway is an essential part of a large dam and provides an efficient and safe means of releasing flood water that exceeds the design capacity of the reservoir.

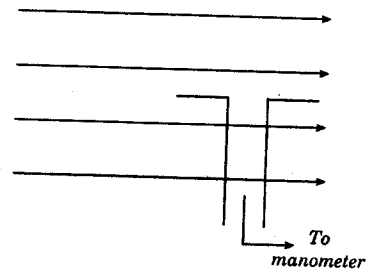
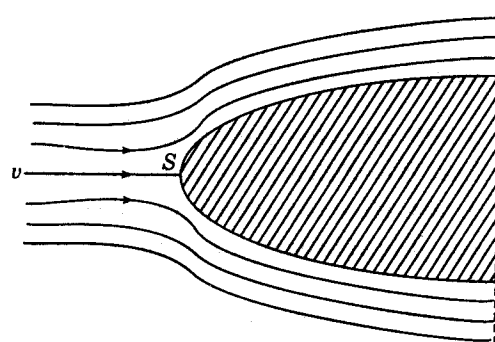
Siphon Spillway is spillway designed to discharge water in a closed conduit under negative pressure.

Q. 623. What is the difference between culverts, stilling basin, and standpipe ?

Culverts are built at the points of lowest valley to pass water across the embankments of high ways or railroads.

Stilling basin is transitional energy dissipating structure to avoid the damaging process by a highly accelerated spilled water.

Standpipe is used principally for alleviating the transient pressures in large pipeline system. It also works as a pressure relief valve for the upstream pipe during the turbine shut off.



Q. 624. What do you understand by run-of-river scheme in hydro power generation ?

Ans. A scheme in which the discharge is varying and only that much water can be utilised for conversion as available in the river.

Q. 625. What is the difference between firm power and secondary power in hydro power plants ?

Ans. The approximate constant and continuous power which is assured at power station and would be available throughout the year is called firm power.

In run-of-the river schemes which are generally designed for 90% availability of water, the firm power would be available for at least 90% of the years during the life of the scheme. However in some years discharge in the river may be more than 90% availability discharge and some extra power known as secondary power can be generated.

Q. 626. What is the criterion for determining economic diameter of power tunnel ?

Ans. The economic diameter of a power tunnel is determined such that the total value of following two factors is least

- (i) annual loss of revenue on account of power head lost due to friction.
- (ii) recurring annual expenditure.

Q. 627. What are the three functions served by a surge tank in a hydro plant ?

Ans. The three functions served by a surge tank are

- (i) flow regulation - act as a reservoir for acceptance or delivery of water to meet requirements of load changes
- (ii) water-hammer relief or pressure regulation.
- (iii) improvement in speed regulation.

Q. 628. What is the criterion to determine the economic diameter of penstock ?

Ans. The economic diameter for a penstock required to carry a discharge is the one at which annual costs due to the greater investment do not exceed the annual value of resulting increment energy output.

Q. 629. If jet ratio for a Pelton wheel is 12 then number of buckets should be ?

Ans. $0.5 \times 12 + 15 = 21$.

Q. 630. What is the difference between anti-friction and hydrostatic bearings ?

Ans. In anti-friction bearings rolling components are introduced between the sliding surfaces. In hydrostatic bearings lubricant is supplied at a high pressure to a pocket in the bearing.

Q. 631. What is inviscid fluid ?

Ans. It is the frictionless fluid.

Q. 632. State law of conservation of momentum ?

Ans. The ratio of change of momentum of a mass of fluid is equal to the vector sum of all external forces acting on it.

Q. 633. Define turbulent flow ?

Ans. Flow in which adjacent layers mix continuously, so that the flow pattern is unsteady, full of eddies, and apparently without any mathematically expressible regularity.

Q. 634. Define Reynold's law of similitude ?

Ans. Two geometrically similar flow systems subject only to friction and inertia forces are dynamically similar if both have the same 'Reynolds' number.

Q. 635. What is the difference between boundary lubrication and fluid film lubrication ?

Ans. In boundary lubrication condition the ratio of thickness of lubrication film to surface roughness (CLA value) is less than 1 and for fluid film lubrication condition this ratio is greater than 5 and less than 100.

Q. 636. A bearing in which hydrodynamic pressure is generated due to rotation of journal is called ?

Ans. Journal bearing.

Q. 637. For a journal running in a bearing clockwise at steady state, where will be the minimum clearance ?

Ans. To the left of the load line.

Q. 638. Out of impulse and reaction type hydraulic turbines, which has higher specific speed ?

Ans. Reaction turbine.

Q. 639. A Francis turbine running at 200 rpm develops a power of 5000 kW under a head of 25 m. If head is changed to 100m, what will be the speed and power output of this turbine ?

Ans.
$$\frac{P_1}{H_1^{3/2}} = \frac{P_2}{H_2^{3/2}}$$

or
$$P_2 = P_1 \left(\frac{H_2}{H_1} \right)^{3/2} = 5000 \left(\frac{100}{25} \right)^{3/2} = 40,000 \text{ kW}$$

Also
$$\frac{N_1}{\sqrt{H}} = \frac{N_2}{\sqrt{H_2}} \text{ or } N_2 = N_1 \sqrt{\frac{H_2}{H_1}} = 200 \sqrt{\frac{100}{25}} = 400 \text{ rpm.}$$

Q. 640. If a centrifugal pump's speed is doubled, how much increase in power will be needed to drive the pump.

Ans. 4 times.

Q. 641. Navier stokes equation represents the conservation of which quantity ?

Ans. Momentum.

Q. 642. If 'p' is the gauge pressure within a spherical droplet, what will be the gauge pressure within a bubble of the same fluid and of same size.

Ans. 2 p.

Q. 643. Clearance volume of a reciprocating compressor is 100 ml and volume of cylinder at dead centre is 1.0 litre. What is the clearance ratio of compressor ?

Ans. Clearance ratio =
$$\frac{\text{Clearance volume}}{\text{Swept volume}} = \frac{100}{1000 - 100} = \frac{1}{9}$$

Q. 644. Fluid is flowing with an average velocity V through a pipe of diameter D. Over a length of L, the head loss is given by $\frac{fLV^2}{2D}$, where f is the friction factor. For a laminar flow, what is the value of f in terms of Reynolds' number Re ?

Ans.
$$f = \frac{64}{Re}$$

Q. 645. What is the name of nondimensional group for ratio of inertia force to gravity force.

Ans. Froude number.

Q. 646. Why diverging section of venturimeter tube is longer than converging section ?

Ans. The angle of diverging section is kept small to reduce the possibility of flow separation.

Q. 647. The head loss in a fully developed laminar flow in a circular pipe due to friction is directly proportional to ?

Ans. Square of mean velocity.

Q. 648. For what type of flow, the streamlines, pathlines and streaklines are virtually identical ?

Ans. Steady flow.

Q. 649. How the streamlines and equipotential lines are related in a flow field ?

Ans. They are orthogonal everywhere in the flow field.

Q. 650. Under what kind and condition of a fluid the velocity potential exists ?

Ans. Irrotational flow.

Q. 651. Where should centre of gravity of a body lie for it to float in stable equilibrium ?

Ans. c.g. should be located below the metacentre.

Q. 652. For a fully developed flow through a pipe, what is the ratio of maximum to average velocity ?

Ans. 2.

Q. 653. Out of centrifugal, axial and positive displacement pumps, which has maximum specific speed and which has minimum ?

Ans. Axial pump has maximum specific speed and reciprocating pump has minimum.

Q. 654. Specific speed of a turbine is 800. What type of turbine is this ?

Ans. Kaplan turbine.

Q. 655. In which type of lubrication system the start friction is low ?

Ans. Hydrostatic lubrication.

Q. 656. At which point the cavitation is most likely to occur in a hydel plant ?

Ans. At turbine rotor exit.

Q. 657. What is the difference between lower pair and higher pair ?

Ans. In a kinematic pair, if the elements have surface contact when in motion, the pair is called lower pair ; and if elements have line or point contact the pair is called higher pair.

Q. 658. What do you understand by inversions and how many inversions are possible in a kinematic chain having 'n' links ?

Ans. Inversions are different mechanisms obtained by fixing different links in a kinematic chain but keeping relative motions of links unchanged with respect to one another. A kinematic chain with 'n' links can have 'n' inversions,

Q. 659. What is the difference between basic kinematic chain and compound kinematic chain ? What is the criteria for a chain to be constrained ?

Ans. A basic kinematic chain consists of four kinematic links and a compound kinematic chain is a constrained chain of more than four links. A chain is constrained if no. of binary joints and half of number of higher pairs is equal to $3/2$ of no. of links minus 2.

Q. 660. What is the difference between a machine and a mechanism ?

Ans. A mechanism consists of links forming a constrained kinematic chain. Its function is basically to transmit or modify motion. A machine is a mechanism but here we are concerned with forces to be transmitted and it is used to modify mechanical work.

Q. 661. In which type of motion, acceleration is directly proportional to displacement ?

Ans. SHM.

Q. 662. What is the magnitude and direction of coriolis component of acceleration ?

Ans. $2\omega v$ and it leads the sliding velocity vector by 90° .

Q. 663. What is the direction of tangential acceleration ?

Ans. The direction of tangential acceleration may be same or opposite to that of angular velocity.

Q. 664. Write is the number of degrees of freedom constrained in each case by the kinematic pairs

(i) Revolute pair, (ii) cylindrical pair, (iii) Screw pair, (iv) Spherical pair.

(UPSC CES 1997)

Ans. (i) Revolute pair - single degree of freedom

(ii) cylindrical pair - two degrees of freedom

(iii) screw pair - one degrees of freedom

(iv) spherical pair - three degrees of freedom.

Q. 665. What is the purpose of D'-slide valve in steam engines ?

Ans. It controls the piston position for cut off of steam, for release of steam and compression position for steam in cylinder.

Q. 666. What is the purpose of Corliss valve in place of D'slide valve in steam engine ?

Ans. Corliss valve reduces condensation, provides independent control on admission, cut off, release and compression, and reduces driving power requirements.

Q. 667. On what factor the size of cam depends ?

Ans. Size of cam depends on base circle.

Q. 668. If base circle diameter of cam increases, what happens to pressure angle ?

Ans. It decreases.

Q. 669. If angular speed of cam is increased two times, how much jerk will be increased ?

Ans. Eight times.

Q. 670. A rigid link placed on a smooth horizontal plane is struck by an impulsive force at a point 20 cm distance from its c.g., such that it starts rotating about a point 5 cm away from the c.g. Determine the radius of gyration of the link and comment on the relative location of three points, viz, point of force application, c.g., and point of rotation.

(UPSC CES 1997)

Ans. Due to impulsive force, link rotates about a point 5 cm away from c.g.

Mass of link provides the restoring couple.

\therefore Impulsive force $F \times (20 + 5) = mg \times 5$

\therefore $F = \frac{mg}{5}$

Impulse $= F \times a = I \alpha$

or $\frac{mg}{5} \times \alpha \times 25 = mg k^2 \alpha$

or $k^2 = 5$ and $k = \sqrt{5}$

All the three points lie on same plane and in one straight line.

Q. 671. What is the relationship between (i) axes of spin, precession, and applied gyroscopic torque and (ii) in between their planes ?

Ans. The axes of spin, precession, and applied gyroscopic torque are contained in two planes perpendicular to each other, and planes of spin, precession, and applied gyroscopic torque in the three planes perpendicular to one another.

Q. 672. For the angle of repose of 30° , what is the maximum efficiency of inclined plane for motion up the plane ?

Ans. $33 \frac{1}{3} \%$.

Q. 673. What is the ratio of frictional torque produced for uniform wear to frictional torque produced for uniform pressure ?

Ans. 3/4.

Q. 674. On what factor the maximum efficiency of screw jack depends ?

Ans. Angle of friction.

Q. 675. To be on safe side which assumption is advisable for working out (i) power lost in friction ? and (ii) power transmitted by friction ?

Ans. Uniform pressure, uniform wear respectively.

Q. 676. State the conditions for a rigid rotor to be dynamically balanced.

(UPSC CES 1997)

Ans. When rotor is rotated at high speed, the vibrations in two planes should be within prescribed limits. Rotor should not be operated near its natural frequency of vibrations.

Q. 677. Why involute profile is preferred to cycloidal for gears ?

Ans. The rack for generating involute profile on gears has straight line profile and hence such gears can be easily cut.

Q. 678. What is the condition for correct gearing ?

Ans. According to condition of correct gearing, the common normal to the pitch surface should cut the line joining the centres at a fixed point.

Q. 679. What is the diameter of rack for gear ?

Ans. Infinite

Q. 680. If criterion for gear design is wear strength, will you prefer $14\frac{1}{2}^\circ$ pressure angle or 20° pressure angle ?

Ans. 20° pressure angle.

Q. 681. What are Herringbone gears and what for these are used ?

Ans. Herringbone gears are double helical gears and used to eliminate axial thrust.

Q. 682. Whether normal pressure angle in helical gear is more or less than ordinary pressure angle ?

Ans. Less.

Q. 683. Whether tooth error is more prominent for spur or helical gears ?

Ans. Spur gears.

Q. 684. Show the variation of the ratio of damped frequency to undamped frequency against damping ratio in case of a damped oscillator ?

(UPSC CES 1997)

Ans. As damping ratio increases, the ratio of damped to undamped frequency decreases nearly exponentially.

Q. 685. A simple gear train has three gear wheels of 25, 10 and 50 teeth respectively. The speed ratio of third gear to first gear and direction are ?

Ans. Half and same direction.

Q. 686. The axes of first and last gear in a reverted gear train are ?

Ans. coaxial ?

Q. 687. Which gear train is used to connect hour hand in clock mechanism to minute hand ?

Ans. reverted gear train.

Q. 688. If there are even number of idlers between driver and driven gears in a simple gear train, then direction of driver and driven gears will be ?

Ans. opposite.

Q. 689. What is the difference between train value and speed ratio of a gear train of n wheels ?

Ans. Train value = $\frac{\text{speed of last gear}}{\text{speed of first gear}}$, and speed ratio is = $\frac{\text{speed of first gear}}{\text{speed of last gear}}$.

Thus both are reciprocal of each other.

Q. 690. How helical gears are capable of transmitting heavy load at high speed compared to spur gears ?

Ans. Helical gears have smooth engagement and two pairs of teeth are always in contact.

Q. 691. Which type of bearing is most suitable for helical gears ?

Ans. Deep groove ball bearing

Q. 692. What is the name given to bevel gears used for connecting non-intersecting shafts ?

Ans. Hypoid gears.

Q. 693. Out of spur, bevel, helical, mitre, herringbone, hypoid, zerol gears, in which case the interchangeability is possible ?

Ans. Spur gears.

Q. 694. Why worm gear drive is used for hoists ?

Ans. Because it is self locking.

Q. 695. What is the material used for worm gear pair ?

Ans. Bronze.

Q. 696. In which type of gear pair heat dissipation is important criterion ?

Ans. Worm gear

Q. 697. A gear train in which axes of gears have motion is called ?

Ans. epicyclic gear train.

Q. 698. If a rigid body is to be replaced by two concentrated masses rigidly connected together then what are the essential conditions for two systems to be kinetically equivalent ?

(UPSC CES 1991)

Ans. (i) Mass of two masses should be same as the mass of rigid body.

(ii) Centre of gravity of two mass system should coincide with the centre of gravity of rigid body.

(iii) Mass moment of inertia of the two mass system and the rigid body about centre of gravity should be equal.

Q. 699. State D' Alembert's principle and write down its importance. (UPSC CES 1989)

Ans. D' Alembert's principle enables us to replace a given system by a massless rigid body so that forces acting on it are equivalent to those on real body and then enables to determine the forces transmitted to other paired rigid body. This way the problem of kinetics gets reduced to equivalent problem on statics.

Q. 700. What is the effect of inertia of reciprocating parts on the engine frame ?

(UPSC CES 1989)

Ans. Inertia of reciprocating parts subjects engine frame to the force required to accelerate the reciprocating mass and thus subject them to primary disturbing force and secondary disturbing force. Secondary disturbing force comes into play due to obliquity of connecting rod and has twice the frequency of the primary force.

Q. 701. How the reciprocating masses of engine is balanced ?

Ans. Four conditions need to be ensured for balancing reciprocating masses

- | | |
|-------------------------------------|--------------------------------------|
| (i) Primary forces must balance | (ii) Primary couples must balance |
| (iii) Secondary forces must balance | (iv) Secondary couples must balance. |

Q. 702. Why only partial primary balance is achieved and not full primary balance in case of reciprocating masses ?

Ans. Balancing mass of same amount as reciprocating mass may balance primary force but introduces another unbalanced vertical force. Thus compromise is affected by balancing only a portion of primary forces.

Q. 703. What is hammer blow in locomotives ?

(UPSC CES 1989)

Ans. Vertical unbalanced force introduced due to balancing weight for balancing primary force at high speeds may be sufficient enough to lift the wheels from the rails and this condition is known as hammer blow.

Q. 704. What are primary and secondary unbalances in a slider-crank mechanism ?

(UPSC CES 1991)

Ans. Inertia force of reciprocating mass in slider crank mechanism is

$$F = m \omega^2 r \left(\cos \theta + \frac{\cos 2\theta}{n} \right) = m \omega^2 r \cos \theta + m \omega^2 r \frac{\cos 2\theta}{n}$$

First element constitutes primary disturbing force and second element the secondary disturbing force. Both elements have to be balanced.

Q. 705. In a spring mass system, mass is doubled and spring stiffness halved. The natural frequency of longitudinal vibration will be ?

Ans. halved.

Q. 706. Define logarithmic decrement. How it is related to damping ratio ?

(UPSC CES 1991)

Ans. Logarithmic decrement expresses the measure of amount of damping in terms of rate of decay of oscillation. It is defined as the natural logarithm of the ratio of any two successive amplitudes of vibration. If damping ratio be ζ , then logarithmic decrement = $2\pi \frac{\zeta}{\sqrt{1-\zeta^2}}$.

Q. 707. In forced vibrations, how the spring force, damping force and inertia force behave in relation to direction of displacement ?

Ans. Spring force is always opposite to displacement, damping force lags by 90° , and inertia force is in phase with displacement.

Q. 708. On what factors depends the critical damping coefficient ?

Ans. Critical damping coefficient depends on mass and natural frequency.

Q. 709. At what value of ω/ω_n , transmissibility ratio is 1 for all values of damping ratios ?

Ans. $\sqrt{2}$.

Q. 710. Under what condition damping is detrimental and under what condition it is beneficial ?

Ans. Damping is detrimental beyond $\omega/\omega_n > \sqrt{2}$ and beneficial when $\omega/\omega_n < \sqrt{2}$.

Q. 711. Differentiate between main function of flywheel and governor. (UPSC CES 1989)

Ans. The function of flywheel is to reduce fluctuation of speed during a cycle and the function of governor is to control the mean speed over a period for output load variations. Flywheel has no influence on mean speed of prime mover and governor has no influence over cyclic speed fluctuation.

Flywheel has no influence over the varying load demand on prime mover but governor adjusts supply energy of prime mover to demand energy from prime mover when output is varying.

Q. 712. On what factor depends the natural frequency of a system ?

Ans. It depends on the mass and stiffness of system.

Q. 713. State the condition for the stability of a governor. Why is an isochronous governor not stable ? (UPSC CES 1991)

Ans. For a governor to be stable, the ratio of controlling force and radius of governor balls (r) must increase with increase in radius. Further controlling force must be zero for a certain value of r and be negative below it.

In isochronous governor, ratio of controlling force and radius of governor is constant for all values of radius and as such it is not able to attain a definite position for particular speed.

Q. 714. State Grashof's law for four-bar linkage mechanism.

Ans. According to it, the sum of the shortest and longest link length can't be greater than the sum of the remaining two link lengths, if there is a continuous relative motion between two members.

Q. 715. State the conditions for a four-bar linkage to be called a Grashof's linkage and also when this linkage would become a double crank mechanism ? (UPSC CES 1992)

Ans. For Grashof's linkage, shortest link is fixed and sum of shortest and longest link is less than the sum of other two links.

For double crank mechanism, two alternate links are of same length and one of larger link is fixed.

Q. 716. What are inversions ?

Ans. Inversions are different mechanisms obtained by fixing different links in a kinematic chain but keeping relative motions of links unchanged with respect to one another.

Q. 717. How many inversions are possible in a kinematic chain having N links.

Ans. N inversions.

Q. 718. Define the coefficient of fluctuation of energy in case of a flywheel. How is it related to the coefficient of fluctuation of speed ? (UPSC CES 1992)

Ans. Coefficient of fluctuation of energy $K_e = \frac{\text{maximum fluctuation of energy}}{\text{work done per cycle (W)}}$

$$K_e = K_s \frac{I \omega^2}{100 W} \quad (K_s = \text{fluctuation of speed ; } I = M \cdot I \text{ of flywheel})$$

Q. 719. When can you say that a vibratory system is critically damped ? How is critical damping coefficient related to mass (m) and spring constant (k) of the system ?

(UPSC CES 1992)

Ans. A vibratory system is critically damped when transition occurs from oscillatory to non-oscillatory condition.

Critical damping coefficient = $2 \sqrt{km}$.

Q. 720. What is a Gyro ? How is gyroscopic torque (T) related to spin velocity (ω_s) and precession velocity (ω_p) ? (UPSC CES 1992)

Ans. Gyro is an instrument in which one rotor spins on its axis. The rotor is precessed at an angle of 90° to axis of spin. Then gyroscopic couple is experienced along an axis which is perpendicular to both axis of spin and axis of precession Gyroscopic Torque $T = I \omega_s \omega_p$.

Q. 721. State when the meshing surfaces can be called conjugate ? (UPSC CES 1992)

Ans. Meshing surfaces are called conjugate when they follow the law of gearing, i.e. the common normal at the point of contact always passes through a pitch point on the line joining the centres of rotation.

Q. 722. Give Klein's construction and its use.

(UPSC CES 1994)

Ans. Triangle representing line joining piston centre and crank rotation point, crank and connecting rod is drawn. Connecting rod line is produced to intersect a perpendicular through crank rotation point on line joining piston centre and crank rotation point. Draw a circle with radius equal

to projected length and centre as common point on connecting rod and crank. Another circle is drawn with piston centre as centre and radius of length of connecting rod. Draw a line joining points cutting two circles and meeting connecting rod at same point. Polygon joining lines of crank, part of connecting rod, line along chord to central axis and line from last point to crank rotation centre is acceleration polygon.

Q. 723. Why is the pressure angle for involute gears always constant ? (UPSC CES 1994)

Ans. Tangent to the base circles is a normal to the involute profile. Thus a common tangent to the base circles is a common normal to the two involutes to the tooth profiles of the gears in mesh. Thus the path of contact is a straight line. Hence the pressure angle for involute gears is always constant.

Q. 724. Under what condition the radius of friction circle increases ?

Ans. With increase in coefficient of friction.

Q. 725. Which angle of contact is considered for working power transmitted by belt drive ?

Ans. Angle of contact on smaller pulley.

Q. 726. For what purpose is done the crowning of the pulleys ?

Ans. To prevent the belt running off the pulley.

Q. 727. What is the basic purpose of flywheel and governor ?

Ans. Basic purpose of flywheel is to influence the cyclic variation of prime mover, whereas the basic purpose of governor is to maintain the speed of the engine within prescribed limits for varying torque output conditions.

Q. 728. Name one spring loaded and one gravity controlled type governor ?

Ans. Hartnell and Proel respectively.

Q. 729. Whether the height of governor increases or decreases with increase in speed ?

Ans. Decreases.

Q. 730. What is a friction circle ? What is the magnitude of its radius ?

(UPSC CES 1994)

Ans. When shaft in a bearing is at rest, its weight acts down through centre of bearing and it is supported by vertical reaction through centre. However when shaft rotates, it does not remain in the centre but tends to climb against direction of rotation. It is then under equilibrium due to its weight, vertical reaction and friction force. The circle formed at tangent to vertical reaction is known as friction circle. Its magnitude is $r \sin \phi$, where ϕ is angle between vertical at displaced position and line joining centre of bearing shaft displaced position. Value of ϕ is very small and thus radius of friction circle can be taken as $r \tan \phi = \mu r$.

Q. 731. The method which gives the acceleration of the elements of a connecting rod of a slider crank mechanism by a simple graphical form is known as ? (UPSC CES 1997)

Ans. Klein's construction.

Q. 732. How the controlling force of governor and speed of governor related ?

Ans. They are inversely proportional.

Q. 733. How sensitivity of governor defined ?

Ans. Sensitivity of a governor is defined as the ratio of mean speed of governor to governor speed range.

Q. 734. For the same maximum fluctuation of energy of a flywheel, if the mean speed of rotation is more then the weight of flywheel will be ?

Ans. decreased.

Q. 735. If 'r' be radius of friction surface, then where the frictional force can be considered to act in case of (a) uniform pressure, (b) uniform wear.

Ans. (a) $2/3 r$, (b) $r/2$.

Q. 736. State Grashof's criterion for movability of a four-bar linkage.

(UPSC CES 1996)

Ans. According to Grashof's criterion, the sum of the shortest and longest link length can't be greater than the sum of the remaining two link lengths.

Q. 737. On what parameters depends the natural frequency of a system ?

Ans. On stiffness and mass of the system.

Q. 738. In an experiment on forced vibration response of a single degree of freedom system, it is found that half-power points lie at frequencies 40 and 44 Hz. Find the damping factor of the system.

(UPSC CES 1996)

Ans. $\delta = \log \frac{44}{40} = \log 1.1$; and $\zeta = \frac{\log 1.1}{2\pi}$..

Q. 739. What are the advantages of spring loaded governors compared to gravity controlled governors ?

Ans. Spring loaded governors are more compact, can operate at higher speeds, and can be fixed at any inclination.

Q. 740. How is sensitivity of governor defined in terms of maximum speed N_{\max} and minimum N_{\min} ?

Ans. Sensitivity = $2 \left(\frac{N_{\max} - N_{\min}}{N_{\max} + N_{\min}} \right)$.

Q. 741. What is the difference between a stable governor and isochronous governor ?

Ans. In stable governor, the ball masses occupy a definite specified position for each speed whereas for isochronous governor the ball masses have same speed for all radii of rotation.

Q. 742. What is the name given to a gear trains where the axes of first and last gear of compound gear train are co-axial ?

Ans. Reverted gear train.

Q. 743. What is the name given to gear trains where the axes of gears have motion ?

Ans. Epicyclic gear train.

Q. 744. Under what condition the resultant unbalanced force is minimum in reciprocating engines ?

Ans. When half of the reciprocating masses are balanced by rotating masses.

Q. 745. Name any two centrifugal governors, which are gravity controlled. State which one is more sensitive.

(UPSC CES 1996)

Ans. Two gravity controlled governors are Portel and Proel. Proel is more sensitive than Portel.

Q. 746. What is the difference between static balancing and dynamic balancing ?

Ans. Static balancing is done for non-rotating parts and dynamic balancing is achieved for rotating parts.

Q. 747. If speed of a system is doubled in which mass 'm' at a distance of 'r' is balanced in same plane by mass 'B' at distance 'b', then mass B would have to be increased times.

Ans. four times.

Q. 748. The balance masses are introduced in the planes parallel to the plane of rotation of disturbing mass. For complete dynamic balance, how many minimum balancing masses need to be introduced.

Ans. 2.

Q. 749. What are the essential conditions to balance the reciprocating mass of reciprocating engine ?

Ans. (i) primary forces must balance (ii) primary couples must balance
(iii) secondary forces must balance.

Q. 750. In reciprocating engines, how much reciprocating masses are balanced by rotating masses in order to ensure that resultant unbalanced force is minimum ?

Ans. Half the reciprocating masses.

Q. 751. For what purpose Scott-Russel mechanism used ?

Ans. For generating a straight line.

Q. 752. What for Klein's construction is mainly used ?

Ans. To determine the linear acceleration of piston.

Q. 753. When does Coriolis component exist ?

Ans. Coriolis component exists whenever a point moves along a path that has rotational motion.

Q. 754. What is the direction of Coriolis component acceleration ?

Ans. It acts in direction perpendicular to sliding surfaces.

Q. 755. What is the direction of Coriolis component acceleration w.r.t. sliding velocity vector ?

Ans. It leads the sliding velocity vector by 90° .

Q. 756. If the elements in a kinematic pair have surface contact when in motion, such a pair is called

Ans. lower pair.

Q. 757. If the elements in a kinematic pair have line or point contact when in motion, such a pair is called

Ans. higher pair.

Q. 758. In a single degree of freedom vibration system, whether damped natural frequency or undamped natural frequency is higher ?

Ans. Undamped natural frequency.

Q. 759. Write the number of degrees of freedom constrained in each case by the kinematic pairs.

(i) revolute pair, (ii) cylindrical pair, (iii) screw pair, (iv) spherical pair.

(UPSC CES 1997)

Ans. (i) Revolute (turning) pair has only single degree of freedom (one relative motion of rotation)

(ii) Cylindrical pair has two degrees of freedom, viz rotation and translation parallel to axis of rotation.

(iii) Screw pair has only one degree of freedom (i.e. either rotation of screw or its translation)

(iv) Spherical pair has three degrees of freedom.

Q. 760. State the Kennedy's theorem with reference to instantaneous centres.

(UPSC CES 1999)

Ans. According to Kennedy's theorem if three kinematic links have plane motions their instantaneous centres lie on a straight line.

Q. 761. Which equation enables determination of coefficient of friction in journal bearing? Write down the equation.

Ans. McKee equation is used to find value of f for sleeve bearings - This equation is

$$f = 0.326 \left(\frac{\mu N}{P} \right) \frac{D}{C} + k.$$

Q. 762. Why is the pressure angle for involute gears always constant? (UPSC CES 1994)

Ans. Involute profile satisfies the condition for law of gearing and thus normal between any two points on involute curves always passes through pitch point, maintaining pressure angle constant.

Q. 763. Define diametral quotient and thermal capacity of a worm gear set.

(UPSC CES 1993)

Ans. Diametral quotient is the ratio of reference diameter to the axial module.

Most worm gear sets have their power capacity limited by the heat dissipation ability by radiation and convection. It depends on housing area exposed to ambient air.

Q. 764. What is resonance? Why is it generally avoided? (UPSC CES 1999)

Ans. Every member of a machine has a natural frequency of vibration. When it operates near exciting speed near to natural frequency, it tends to vibrate heavily, such a condition being known as resonance, and it may damage itself and other components. To avoid damage the operation at resonance needs to be avoided.

Q. 765. When do you prefer a belt drive to a gear drive? (UPSC CES 1999)

Ans. Belt drive is preferred for transmission over long distance where some slip can be tolerated. Belt drive also helps in absorbing shock loads and damping out the effects of vibrating forces. Power rating is limited to 100 kW but initial cost is very low compared to gear drive.

Q. 766. What is a higher pair?

Ans. When two elements of a machine have line or point contact, it is referred to as higher pair.

Q. 767. A device that controls $\delta N/\delta T$ (change in speed/change of time) is called

Ans. flywheel.

Q. 768. What is the order of efficiency of flat belt and V-belt drive?

Ans. Flat belt - 98% ; V-belt - 70-96%.

Q. 769. What is big advantage of flat belt drive compared to V-belt or gear drive.

Ans. Flat belt drives produce little noise and absorb more torsional vibration from the system.

Q. 770. How the more power can be transmitted by flat belt?

Ans. By increasing initial belt tension.

Q. 771. Why V-belts are used for long distance transmission?

Ans. If V belts are used for long distance then there will be excessive vibration in slack side which will shorten the belt life materially.

Q. 772. Chainlife gets sacrificed if velocity ratio is high. What is the optimum value?

Ans. 6 : 1.

Q. 773. Sintered metal pads are used as friction materials for brakes and clutches? What are these made of?

Ans. Sintered metal pads are made of a mixture of copper and/or iron particles with friction modifiers, moulded under high pressure and then heated to a high temperature to fuse the material.

Q. 774. How the energy dissipated during clutching operation related to initial angular velocities, inertias I_1 and I_2 , and clutch torque?

Ans. Energy is $\propto (\omega_1 - \omega_2)^2$, Also it is $\propto \frac{I_1 I_2}{(I_1 + I_2)}$

It is independent of clutch torque.

Q. 775. What is the ratio of torques for uniform wear and uniform pressure if $D = 2d$ in a clutch plate ?

$$\text{Ans. } T_{uw} \propto \frac{D+d}{4} \propto \frac{3d}{4} ; T_{up} \propto \frac{D^3-d^3}{(D^2-d^2)} \propto \frac{7d}{3 \times 3} ; \therefore T_{uw}/T_{up} = 27/28.$$

Q. 776. What are the different approaches for design of clutches and what is the difference ?

Ans. Two approaches for design of clutch are : (i) uniform wear and (ii) uniform pressure.

In uniform wear approach, after initial wear has taken place on outer surfaces, they get worn down to the point where uniform wear becomes possible.

In uniform pressure approach, springs are employed to obtain a uniform pressure over the area.

Q. 777. What are the desirable characteristics of friction materials for clutches and brakes ?

Ans. (i) High and uniform coefficient of friction

(ii) Imperviousness to environmental conditions

(iii) Ability to withstand high temperatures, good heat conductivity

(iv) good resiliency

(v) high resistance to wear, scroing and galling.

Q. 778. What is the effect of centrifugal tension on a belt and at what speed it needs to be accounted for ?

Ans. Effect of centrifugal force is to create an additional tensile stress on the belt. It results in loss in power transmitted. It needs to be considered above velocity of 900 m/min.

Q. 779. Which compact transmission drive would you recommend for constant speed ratio, high loads and speeds ?

Ans. gear drives.

Q. 780. Why pinion should be made from superior material than gear ?

Ans. Pinion is subjected to longer number of cycle than gears and thus wear is higher.

Q. 781. What type of spring would you recommend for applications requiring variable stiffness ?

Ans. Conical (volute) spring.

Q. 782. What type of spring would you recommend for applications requiring high capacity springs into small space.

Ans. Belleville spring.

Q. 783. Why laminated spring is made of several leaves of decreasing length ?

Ans. In a single leaf spring, the width of centre should be large to take bending load in centre. To achieve same requirement, a number of leaves of decreasing length are stacked one above other.

Q. 784. What is the minimum angle of arc of contact of a flat belt ?

Ans. 155°.

Q. 785. How much is the pulley groove angle for V-belts ?

Ans. 40°.

Q. 786. How are V-belts classified ?

Ans. V-belts are classified by letters A, B, C, D and E depending on the belt cross section and inner length of the belt.

Q. 787. How the connecting rod is balanced ?

Ans. Connecting rod is balanced by considering 2/3rd weight of rod at crank pin as rotating and 1/3rd on gudgeon pin as reciprocating one.

Q. 788. Which parameter decides whether a helical spring is close coiled or open coiled ?

Ans. Helix angle.

Q. 789. Which fibre of helical spring is subjected to higher stress ?

Ans. Inner fibre.

Q. 790. What is self energising brake ?

Ans. In a self energising brake, the friction acts so as to assist in applying the brake.

Q. 791. When a brake becomes self locking ?

Ans. In a self locking brake the extent of self energising is so much that no external force is required to apply the brake.

Q. 792. Why it is usual to employ double opposed shoe brakes instead of single shoe brake ?

Ans. Single shoe brake experiences problem of unbalanced normal force exerting heavy pressure on shaft and bearing. The unbalanced forces are eliminated in double opposed shoe brakes.

Q. 793. Why flat surfaces in boilers need to be supported by stays but not the cylindrical or spherical surfaces ?

Ans. Flat surfaces exposed to pressure tend to bulge out and thus need to be supported by stays. However spherical and cylindrical surfaces have no such tendency.

Q. 794. What is the difference between clutch and coupling ?

Ans. Clutch can be engaged or disengaged at the will of operator but coupling is fixed type in this regard.

Q. 795. On what factors depends the accuracy of a power screw ?

Ans. Efficiency of a power screw depends upon the helix angle and coefficient of friction.

Q. 796. At what value of helix angle the efficiency of power screw is maximum ?

Ans. 40–45°.

Q. 797. What is the difference between crown bevel gear and mitre bevel gear ?

Ans. In crown gear the pitch angle is 90° and in mitre gears the axes of gears are at 90° and gears are of same size.

Q. 798. Define virtual number of teeth for a bevel gear ?

Ans. Virtual number of teeth is actual number of teeth divided by cosine of pitch cone angle.

Q. 799. What is the difference between contact length and contact ratio for gears ?

Ans. Contact length is the distance between points when contact between two gear teeth starts and ends. It is thus the distance between following two points, (i) when the addendum circle of the driven gear intersects the pressure line, (ii) when the addendum circle of the driver intersects the pressure line.

The contact ratio is the ratio of contact length and the base pitch.

Q. 800. What is the value of tip diameter and root diameter of a spur gear in terms of module and number of teeth.

Ans. Tip diameter = module (no. of teeth + 2)

Root diameter = module (no. of teeth – 2.5).

Q. 801. Define module (m) in terms of

(i) circular pitch (p), (ii) diametral pitch (P), and (iii) pitch diameter (d).

Ans. $m = \frac{p}{\pi} = \frac{1}{P} = \frac{d}{\text{no. of teeth}}$

Q. 802. When two gear teeth are in mesh, where does the pure rolling action take place ?

Ans. At pitch point.

Q. 803. What is pressure line in the gears ?

Ans. A line passing through pitch point and drawn tangential to base circles is known as pressure line. All points of contact of two teeth lie on it.

Q. 804. What do you understand by conjugate action in gears ?

Ans. When two meshing gears satisfy the fundamental law of gearing, they are said to produce conjugate action.

Q. 805. What is the fundamental law of gearing ?

Ans. The shape of the teeth of a gear must be such that the common normal at the point of contact between two teeth must always pass through a fixed point on the line of centres.

Q. 806. What is crown gear ?

Ans. A crown gear is a bevel gear with a reference cone angle of 90° .

Q. 807. Which gear drive can be used for non-parallel, non-intersecting shafts ?

Ans. Worm gears.

Q. 808. What is the most important characteristic of involute gear ?

Ans. In involute gears, the centre distance can be altered without destroying the correct tooth action.

Q. 809. Why the portion of a gear tooth below the base circle cut as a radial line and not an involute curve.

Ans. To avoid interference.

Q. 810. What happens if a tooth is stubbed, i.e. a portion of tip is removed to avoid interference ?

Ans. This reduces the contact ratio and produces noisier and rougher gear action.

Q. 811. What is the condition to satisfy that there is no interference in two gears of teeth T and t , and pressure angle of ϕ .

$$\text{Ans.} \left[1 + \left(\frac{t^2}{T^2} + 2 \frac{t}{T} \right) \sin^2 \phi \right]^{1/2} - 1 < \frac{2}{T}$$

Q. 812. For what purpose, auto-collimeter is used ?

Ans. It is used to check angle.

Q. 813. High damping will reduce the transmissibility only when ω/ω_n (i.e. ratio of forcing frequency to natural frequency) is ?

Ans. greater than $\sqrt{2}$.

Q. 814. Under what shape of cam the follower will have constant acceleration ?

Ans. parabolic shape.

Q. 815. How is the life of a ball bearing related to load ?

Ans. Life is inversely proportional to $(\text{load})^3$.

Q. 816. What is the quality of stable governor ?

Ans. The balls of a stable governor occupy a definite specified position for each speed.

Q. 817. On what factor depends the maximum fluctuation of energy of a flywheel ?

Ans. It depends on coefficient of fluctuation of speed, square of angular velocity of flywheel, and moment of inertia of flywheel.

Q. 818. On what factor the stopping distance of four wheel vehicle depends ?

Ans. Stopping distance is proportional to square of velocity of vehicle and decreases with increase in coefficient of tractive coefficient.

Q. 819. What is the effect of weight of vehicle on stopping distance ?

Ans. Stopping distance is independent of weight of vehicle.

Q. 820. On which wheels of vehicle the net reaction is reduced when due to gyroscopic couple when it is negotiating a curve ?

Ans. Inner wheels.

Q. 821. The air screw of an aeroplane is rotating clockwise when looking from front and it makes a right turn. What will be the effect of gyroscopic couple ?

Ans. Nose will be raised and tail depressed.

Q. 822. What is the relative position of planes of spin, precession and applied gyroscopic torque ?

Ans. They are in three planes perpendicular to one another.

Q. 823. What is isochronous governor ? When it is desirable ?

Ans. For isochronous governor, the equilibrium speed is constant for all radii of rotation of the balls within working range. It is desirable when one constant speed is desired to be kept for all loads.

Q. 824. What is pressure angle for a cam and what is its importance ? (UPSC CES - 1988)

Ans. Pressure angle is the angle at any point on the pitch curve, included between the normal to that point on the curve and line of motion of the follower at that instant. It represents steepness of cam profile.

Q. 825. What is the difference between trace point and pitch point w.r.t. cam.

Ans. Trace point is the point on the follower (at knife edge or centre of roller). It is a reference point on the follower for the purpose of tracing the cam profile. Pitch point is the point on the cam pitch curve having the maximum pressure angle.

Q. 826. What is the difference between base circle and prime circle of a cam ?

Ans. Both are smallest circles drawn from the centre of rotation of the cam ; base circle is smallest circle drawn to the cam profile and prime circle is smallest circle drawn to the pitch curve.

Q. 827. In which shape of gear teeth the interference is inherently absent ?

Ans. Cycloidal teeth.

Q. 828. State whether involute or cycloidal teeth have less wear and why ?

Ans. Cycloidal teeth have less wear because convex flank is always in contact with concave. In involute gears, convex surfaces are in contact.

Q. 829. Whether cycloidal or involute teeth are more strong and why ?

Ans. Cycloidal teeth are stronger because they have spreading flanks whereas involute gears have radial flanks.

Q. 830. In which system, some latitude in centre distance can be tolerated ?

Ans. In involute system.

Q. 831. On which angle of contact the power transmitted by belt drive designed ?

Ans. Angle of contact on smaller pulley.

Q. 832. If centrifugal tension is considered in a belt driven then on what factor depends the maximum permissible velocity ?

Ans. Max. permissible velocity is proportional to square root of maximum tension in a belt drive, if centrifugal tension is considered.

Q. 833. How the power transmitted by belt can be increased ?

Ans. It can be increased by (i) increasing initial tension of belt, (ii) dressing belt material to increase value of μ (iii) increasing the angle of lap on smaller pulley by using idlers.

Q. 834. A vessel containing fluid is moving horizontally at acceleration 'a'. What angle will be made by free surface w.r.t. horizontal plane.

Ans. $\tan \theta = a/g$.

Q. 835. What is self locking taper and what is self releasing taper ? Give an example of each where they are used. (UPSC CES 1998)

Ans. Self locking taper is that in which tangent of angle of taper is less than coefficient of friction and it is self releasing when tangent of angle of taper is more than coefficient of friction. Drills usually have self locking taper at shank. Cotter joints are provided self releasing taper.

Q. 836. What are extreme pressure lubricants ? What are the main additives and how do they act ? (UPSC CES 1998)

Ans. Extreme pressure lubricants form layered structures which are easily sheared in sliding thus reducing friction forces and wear. EP additives are compounds of sulphur and chlorine (like chlorinated paraffins, elemental sulphur, or sulphurised fats). They react chemically with the metal to form compounds on the metal surface. These are used for more severe cutting action.

Q. 837. When using strain-gauge system for stress/force/displacement measurements how are in-built magnification and temperature compensation achieved ? (UPSC CES - 1998)

Ans. Four strain gauges are used connected in Wheatstone bridge configuration to achieve built-in magnification and temperature compensation.

Q. 838. How are porous bearings made and where are they used ? (UPSC CES 1998)

Ans. Porous bearings are made by powder metallurgy technique. These are used for applications where frequent lubrication can't be provided and lubrication during manufacture will be sufficient for life time and such bearings are porous enough and are oil impregnated and are self lubricating type.

Q. 839. What is Kennedy's theorem ? (UPSC CES - 1995)

Ans. Kennedy's theorem is also known as Three - centre - in - line theorem. According to it, if three kinematic links have plane motions their instantaneous centres lie on a straight line. It facilitates in locating the instantaneous centres.

Q. 840. What conditions must be satisfied by kinematically equivalent systems ? (UPSC CES 1995)

Ans. (i) The mass of the two systems must be same.

(ii) Centre of gravity of two systems must fall at the same position.

(iii) Mass moment of inertia of the two systems must be the same.

Q. 841. What is hunting of governor ? (UPSC CES 1995)

Ans. Hunting is said to occur in a governor when it is not able to find a stable position for a change in load at a new value of speed and oscillates around it due to tendency of balls and sleeve to restore original speed and inertia effect leading to overshoot of desired position.

Q. 842. A stone tied at the end of a string is whirled in a vertical circle at constant speed. In which position the tension in string will be maximum ?

Ans. When the string is at the bottom of the circle.

Q. 843. What type of gearing is used to obtain large speed reductions (> 20 : 1) in one stage of gear train ?

Ans. worm gearing.

Q. 844. The natural frequency of an undamped vibrating system is 100 rad/s. A damper with a damping factor of 0.8 is introduced into the system. What will be the frequency of damped system ?

Ans. $w_d = w_n \sqrt{1 - \zeta^2} = 100 \sqrt{1 - 0.8^2} = 60 \text{ rad/s.}$

Q. 845. The life of a ball bearing at a load of 10kN is 8000 hours. If load is increased to 20kN, keeping all other conditions same, what will be new life ?

Ans. $\frac{L_2}{L_1} = \left(\frac{P_1}{P_2}\right)^3$ or $L_2 = 8000 \left(\frac{10}{20}\right)^3 = 1000 \text{ hrs.}$

Q. 846. Name metals having recrystalline temperature below room temperature ?

Ans. Zinc, lead, tin.

Q. 847. Under what conditions straight polarity is used in arc welding ?

Ans. The straight polarity is used for arc welding when more heat is required at the work piece side for the thicker sheets or for the materials that have high thermal conductivity like aluminium, copper.

Q. 848. What are the characteristics of tool material ?

Ans. The characteristics of tool material are : (i) Red hardness (ii) Toughness (iii) Co-efficient of friction (iv) Abrasive resistance (v) Thermal conductivity and specific heat (vi) Chemical stability and (vii) Machinability.

Q. 849. List the factors affecting machinability ?

Ans. The factors affecting machinability are (1) Hardness (2) Tensile/Yield strength (3) Carbon content (4) Grain size (5) Tool geometry (6) Cutting fluid (7) Rigidity of cutting tool.

Q. 850. Why are shafts generally finished by grinding while beams are used in as rolled condition ? (UPSC CES 1985)

Ans. Shafts are rotating elements and beams are fixed. Shafts are subjected to dynamic stresses and fatigue loading. In order to increase endurance strength, surface of shafts need to be finished by grinding.

Q. 851. Define cold working of metals and what changes they undergo?

Ans. When the metal is deformed below its recrystallisation temperature then the process is called cold working. When material is cold worked the grain structure changes because of cold working, the material gets hardened and permanently deformed and also internal stresses are set up in metals. It requires stress relieving operation.

Q. 852. Name the various external and internal defects in welds ?

Ans. External weld defects

Incorrect profile, Cracks, Spatter, Edge melted off.

Internal weld defects

Blow holes and internal porosity, Cracks, Inclusions, Lack of fusion, Incomplete penetration.

Q. 853. What is the function of the core in sand mould ?

Ans. Core is defined as any projection into the mould for making cavities and hollow shapes which cannot be produced by pattern alone. Casting are required to have holes, recesses etc of various sizes and shapes. The impressions are obtained by using sand core separately in core boxes.

Q. 854. ASA system specifies tool signatures as 110 20 7 6 8 15 1/32. What does it signify ?

Ans. Tool signature is the identification of tool in the order as follows :

110 : Back rake angle (γ_y)

20 : Side rake angle (γ_x)

7 : End relief angle (α_y)

6 : Side relief angle (α_x)

8 : End cutting edge angle β_e

15 : Side cutting edge angle β_s

1/32 : Nose radius.

Q. 855. What are the factors of evaluating machinability ?

Ans. Following factors are used for machinability :

(i) Tool life

(ii) Rate of metal removal

(iii) Power required

(iv) Surface texture and size of component

(v) Temperature of tool (or) chip.

Q. 856. Is hot working possible at room temperature and for which metals ?

Ans. Yes, for lead and tin.

Q. 857. What kind of chips are encountered when machining mild steel and cast iron ?

Ans. (a) Mild steel — Continuous chip without BUE
(b) Cast iron — Discontinuous chip without BUE

Q. 858. Differentiate between single spindle automats and multi spindle automats.

Ans. Single spindle	Multi spindle
1. There is only one spindle	There are 2, 4, 5, 6 (or) 8 spindles
2. Only one workpiece is machined at a time	A number of workpieces are machined at a time
3. The rate of production is low	Rate of production is high
4. Tool setting time is less	Tool setting time is more

Q. 859. What is indexing ?

Ans. The indexing is the operation of dividing the periphery of a piece of workpiece into any number of equal parts.

Q. 860. Comment on the machined surface characteristics obtained after the EDM process. (UPSC CES 2001)

Ans. The accuracy and surface finish in EDM process can be controlled by varying the frequency and current. Tolerance of the order of 0.05 mm can be easily achieved. Surface finish of the order of 0.4 μm CLA is possible. The surface consists of microscopic craters and the quality of the machined surface mainly depends on the energy per pulse. Surface produced has a matt appearance.

Q. 861. Name four parts of feeding devices in automation. (UPSC CES 2000)

Ans. Transfer system
Indexing mechanism
Feeder
Part Orienting system.

Q. 862. Explain briefly the characteristic feature of stretch forming. (UPSC CES 2000)

Ans. In stretch forming, two opposite edges of sheet or formed section are gripped in pairs and moved to pull the sheet against the contour of a stationary form block until the metal stretches to conform to the contour of the block.

Q. 863. List four parameters to be considered in the gating design for moulds.

(UPSC CES 2000)

Ans. Four parameters are :

- (i) It should promote temperature gradients favourable for directional solidification.
- (ii) Entering velocity of metal should be least and free from turbulence to avoid erosion of the mould.
- (iii) Gating system be rammed harder than mould cavity.
- (iv) Gates should lead metal to the heavier sections of a casting.

Q. 864. What is the relationship for Merchant's constant in machining operation ?

Ans. Merchant's constant $C = 2 \times \text{shear plane angle} + \text{angle of friction} - \text{shear angle}$.

Q. 865. What is the composition of free machining brass ?

Ans. 58% Cu, 39% Zn, 3% Pb.

Q. 866. What is adhesion wear and what is its effect ?

Ans. Adhesion wear occurs mainly at low machining temperatures on the chip face of the tool. It leads to formation of built up edge, between the chip and the edge.

Q. 867. What is the difference between flank wear and crater wear ?

Ans. Flank wear occurs on the flanks of cutting edge due to abrasive wear and it leads to poor surface texture. Crater wear occurs on the rake face due to abrasive and diffusion wear mechanisms. It can be minimised by increasing hot hardness and minimising affinity between materials.

Q. 868. Name two criteria for cutting tool life. (UPSC CES 2000)

Ans. Two criteria for cutting tool life are (i) Cutting speed and (ii) physical properties of workpiece.

Q. 869. Give reasons for hot cracks in the weld metal ?

Ans. The reasons for hot cracks in the weld metal are :

- (i) More sulphur content in weld metal and inadequate quantity of manganese to take care of sulphur
- (ii) Due to uneven cooling of the weld metal and improper welding techniques
- (iii) Poor weldability of parent metal.

Q. 870. What are the factors affecting the rate of feed in a milling machine ?

Ans. The factors which affect the rate of feed in a milling machine are :

1. Helix angle
2. Relief and clearance angles
3. Rake angle.

Q. 871. State four advantages of broaching ?

- Ans.**
1. Both roughing and finishing operations are completed in one pass of the tool.
 2. High rate of production
 3. Little skill is required to perform a broaching operation
 4. Non-standard holes can be produced.

Q. 872. State the important parts of twist drill as per Indian standard ?

Ans. As per Indian standard the important parts of twist drill are as follows :

Axis — The longitudinal centre line of the drill

Shank — That portion of the drill by which it is held and driven

Tang — The flattened end of a taper shank intended to fit into the slot in the socket and to be used for ejection purposes.

Flute — A groove in the body of the drill for removal of chips.

Q. 873. What is JIT ? What is the primary benefit derived from it ? (UPSC CES 2001)

Ans. JIT refers to concept of just in time machining. It is based on the assumption that spares and inventories can be procured in predictable time period and thus the inventory gets reduced to minimum or nil and production cost is thus reduced.

Q. 874. Why a large sphere solidifies and cools to ambient temperature at a much slower rate than does a small sphere ? (UPSC CES 2001)

Ans. Solidification time (ST) $\propto \left(\frac{V}{R}\right)^2$; For sphere, $ST \propto \frac{4/3 \pi r^3}{4 \pi r^2} \propto r$

Since solidification time is proportional to 'r', bigger sphere will take more time for solidification..

Q. 875. What is diffusion welding ? (UPSC CES 2001)

Ans. The two parts to be joined are finished to a high standard of flatness and wrung together under pressure in inert atmosphere.

Q. 876. Distinguish between computer education and computerised education ?

(UPSC CES 2001)

Ans. Computer education is concerned with study of computer hardware and software, programs and programming languages etc. Computerised education is concerned with imparting

education on any subject with the aid of computer, making subject simpler, interesting and absorbing.

Q. 877. Under what condition a taper is self releasing ?

Ans. A taper is self releasing when taper ratio = $2 \times$ coefficient of friction.

Q. 878. What are the units of specific power consumption and specific removal rate in metal cutting ?

Ans $W/mm^3/s$, $mm^3/s/W$ respectively.

Q. 879. According to Merchant's theory of metal cutting, what is the relationship between shear plane angle θ , rake angle γ , and chip thickness ratio $r_c (t_1/t_2)$?

$$\text{Ans. } \tan \theta = \frac{r_c \cos \gamma}{1 - r_c \sin \gamma}$$

Q. 880. Using Merchant's analysis, sometimes value of coefficient of friction of more than 1 is found which is invalid friction coefficient. What is the reason for this ?

Ans. In actual practice the normal conditions of sliding friction do not apply at the chip tool interface. Occurrence of pressure welding at chip and tool rake face confirms this.

Q. 881. What is anisotropy ?

Ans. The phenomenon of different properties in different directions is called anisotropy.

Q. 882. Differentiate between cold, warm and hot working of metals. (UPSC CES 2001)

Ans. If metals are worked above recrystallisation temperature, it is referred to as hot working. Working below recrystallisation temperatures is called cold working. Warm working is in-between condition, i.e. working near recrystallisation temperature.

Q. 883. Which factors affect tool size ?

Ans. Following factors influence tool size :

1. Process variable (speed, feed and depth of cut)
2. Tool material
3. Tool geometry
4. Work piece material, its hardness, microstructure and surface condition
5. Cutting conditions.

Q. 884. List the types of driving mechanisms used in slotter for driving the ram ?

Ans. The following quick return mechanisms are generally used in a slotter :

- (i) Whit worth quick return mechanism
- (ii) Variable speed reversible electric motor drive
- (iii) Hydraulic drive.

Q. 885. How is the size of a vertical boring machine designated ?

Ans. The specifications of vertical boring machine are :

- | | |
|---------------------------|------------------------|
| (i) Column height | (ii) Table size |
| (iii) Floor area | (iv) Weight of the job |
| (v) Spindle of the motor. | |

Q. 886. What do you mean by drill sleeve and a drill socket ?

Ans. The drill sleeve is suitable for holding only one size of shank. If the taper shank of the tool is smaller than the taper in the spindle hole, a taper sleeve is used.

When the tapered tool shank is larger than the spindle taper, drill sockets are used to hold the tools. Drill sockets are much longer in size than the drill sleeves.

Q. 887. Differentiate between gear hobbing and gear shaping with reference to various relative motions and applications. (UPSC CES 1999)

Ans. Gear hobbing is a continuous indexing process in which both cutting tool (a hob) and work piece rotate in a constant relationship while the hob is being fed into work. Hob is also imparted a radial feed.

Gear shaping uses a pinion type of cutter which is reciprocated with required cutting speed along the face of workpiece and is gradually fed radially to plunge. Continuous generation motion is obtained by feeding cutter to full depth and rotating the cutter and workpiece slowly.

Q. 888. What are the ingredients of stainless steel and what are their approximate percentages? (UPSC CES 1998)

Ans. The main ingredients of stainless steel are chromium — 18%, nickel — 8%. Extra low carbon stainless steel have carbon content as low as 0.03%. Precipitation – hardenable stainless steel have age – hardening elements, viz., titanium, aluminium, copper, molybdenum, columbium and tantalum.

Q. 889. The best shape of a runner in sand casting is an inverted frustum of a cone — why? (UPSC CES - 1998)

Ans. Tapered shape with bigger diameter at top and smaller at bottom ensures avoidance of entrainment or absorption of air/gases into the metal while passing through the runner.

Q. 890. State standard point angle and helix angle of a twist drill. (UPSC CES 1998)

Ans. Standard point angle of twist drill is 118° and helix angle varies from 16° to 30° depending as diameter of hole.

Q. 891. State two products each produced by forward extrusion and reverse impact extrusion. (UPSC CES - 1998)

Ans. Two examples of products made by direct extrusion are : gear profile, solder wire.

Two examples of reverse impact extrusion are : Short tubes of soft alloys, tooth paste containers.

Q. 892. What are the best geometrical shapes suggested for sheet metal drawing and spinning? (UPSC CES - 1998)

Ans. Cup shape is best suited by drawing operation. Conical shape is easiest to produce by spinning operation.

Q. 893. Multiple coated, disposable carbide tips have more-or-less replaced brazed carbide tipped tools in CNC applications. Why? (UPSC CES - 1998)

Ans. Disposable tips are usually indexable type and have a number of cutting edges. Very convenient gripping devices for holding such inserts on tool holders are available. A wide variety of ready made inserts are available which require no grinding or adjustment.

Q. 894. State, sequentially elements of a canned CNC drilling cycle. (UPSC CES - 1998)

Ans. Canned cycles are fixed cycles for general sequences of operations. For drilling operation, sequence of operations will be movement of drill or workpiece to position of actual drilling, movement of drill downwards till it is in the proximity of workpiece, then movement of drill at desired feed rate to sufficient depth of hole, retracting the drill above the workpiece.

Q. 895. What is the advantage of independent jaw chuck?

Ans. Irregular job can be fixed.

Q. 896. Mention the major difference between drilling and boring?

Ans.	Drilling	Boring
(a)	It is the operation of initiating a hole	Boring is the operation of enlarging a drilled hole
(b)	It can produce only standard holes	We can produce non-standard hole
(c)	Drill is a multi point tool	A single point tool is used

Q. 897. Why are hydrodynamic bearings used for grinding machines in preference to ball or roller bearings ? (UPSC CES 1999)

Ans. Hydrodynamic bearings are more suitable at high speed, better tolerances, quiet operation, higher capacity to withstand shock, lesser space requirement, better life under fatigue conditions etc.

Q. 898. Mention the name of the process by which the following are manufactured :

- (i) Tungsten carbide tools (ii) engine cylinder block
(iii) connecting rod (iv) plastic buckets. (UPSC CES 1999)

Ans. (i) WC tools by powder metallurgy process

(ii) engine cylinder block by casting

(iii) connecting rod - forging

(iv) plastic bucket - compression moulding.

Q. 899. Distinguish between a jig and fixture. (UPSC CES 1999)

Ans. Jig clamps and locates parts in positive manner and guides cutting tools (drills, reamers, taps etc). Fixture is bolted or fixed securely to the machine table so that work is in correct locationship to the cutter. Fixtures are used for mass milling, turning and grinding, etc.

Q. 900. State the similarities and differences between a fixture and a jig. (UPSC CES 1998)

Ans. Both jig and fixture positively locate, hold and clamp the workpiece. Jigs guide the tool for drilling etc but fixture has no facility to guide the cutting tools. Jigs are used for drilling etc and fixture for mass milling, turning, grinding, etc.

Q. 901. Describe two distinguishing features of robots, which make them different from conventional material handling equipments ? (UPSC CES 1999)

Ans. Robots are flexible in the sense that by changing program they can be made to perform a variety of material handling jobs. They are intelligent because of sensors and computers and are more precise than other material handling devices.

Q. 902. A right hand helical gear is being cut on a milling machine. What changes in machine settings have to be made to cut a left hand helical gear of same pitch and number of teeth ? (UPSC CES 1999)

Ans. For cutting right hand helical gear right side of milling table is tilted up from normal position by the helix angle. For cutting left hand helical gear, right side of table needs to be tilted down at helix angle, all other settings remaining unchanged.

Q. 903. What is the direction of movement of the carriage while cutting left hand thread on a lathe ? (UPSC CES 1999)

Ans. The carriage moves away from headstock towards tail stock for cutting left hand thread.

Q. 904. Why a drill can not drill deeper than its flute length ?

Ans. If flute submerges in a drilled hole, the chips disposal passage is blocked and the drill will get jammed in the hole.

Q. 905. When do you recommend the use of straight fluted drill ?

Ans. Drills used for brass and other soft materials and thin sheets need not be provided with any helix angle, to prevent the lips digging into the workpiece.

Q. 906. Under what condition a drill may not cut ?

Ans. When the cutting lips are not provided with clearance angles. It will cut if 12° clearance angle is ground.

Q. 907. Specify the volume of oxygen and acetylene to get (a) natural flame (b) oxidising flame ?

Ans. (a)	Natural flame	(b)	Oxidising flame
	Oxygen - 50%		Oxygen - 65%
	Acetylene - 50%		Acetylene - 35%.

Q. 908. Name the tools used for hole starting, hole enlarging, and hole finishing.

Ans. Tools used for hole starting are – twist drills, centre drills, flat drills and drill bits

Hole enlarging — boring tools, core drills, counter bores

Hole finishing — reamers, taps.

Q. 909. Some drills have straight shanks and some have tapered shank. Why ?

Ans. Small drills (less than 12 mm diameter) are provided with straight shanks which can be held in drill chucks. Bigger drills have tapered shank using self holding Morse tapers which prevent gravitational fall of drill.

Q. 910. What are the main factors that are responsible for the formation of built up edge ?

Ans. The main factors that are responsible for the formation of built up edge are :

1. Extreme pressure in the cutting zone
2. High friction in the tool chip interface
3. High local temperature.

Q. 911. How specific cutting pressure behaves with feed rate and what conclusion can be drawn from this ?

Ans. As feed rate increases, the specific cutting pressure decreases. It leads to conclude that feed rates be maximised in metal cutting process.

Q. 912. For rough turning, what is the ratio between tangential cutting force F_c , radial force F_r , and axial F_a force.

Ans. $F_c : F_r : F_a = 4 : 2 : 1$

Q. 913. What are the qualities of ideal tool material ?

Ans. It should be hard to resist flank wear and deformation, have high toughness to resist fracture, be chemically inert to the workpiece, be chemically stable to resist oxidation and dissolution, and have good resistance to thermal shocks.

Q. 914. What are the factors to be considered while evaluating the machinability ?

- | | | |
|---|--|--------------------------|
| Ans. 1. Tool life | 2. Rate of metal removal | 3. Power required |
| 4. Surface texture and size of component | 5. Temperature of tool (or) chip. | |

Q. 915. How to judge the unsatisfactory performance of cutting tool ?

Ans. Unsatisfactory performance of cutting tool leads to loss of dimensional accuracy, increase in surface roughness and increase in power requirements.

Q. 916. What does good machinability imply ?

Ans. Good machinability implies low cutting force, less tool wear, good surface finish.

Q. 917. What are the criteria for judging machinability ?

Ans. Cutting speed, tool life, surface finish, cutting force/energy required, temperature rise at cutting point.

Q. 918. How tool wear is specified ?

Ans. It is specified by crater wear and flank wear.

Q. 919. What is the function of a lathe bed ?

- Ans.** 1. It prevents deflection under tremendous cutting pressure transmitted through the tool post and carriage to the lathe bed
 2. It absorbs vibration
 3. It resists the twisting stress setup due to the resultant of two forces.

Q. 920. What is cellular manufacturing layout ?

Ans. In cellular manufacturing layout, machines are grouped into cells functioning like a product layout. Each cell in cellular manufacturing layout is formed to produce a single parts family or a few parts with common characteristics, *i.e.* parts which require the same machines and similar machine settings.

Q. 921. Differentiate between counter sinking and counter boring ?

Ans. Counter boring : The operation of enlarging a hole through a certain distance from one end instead of enlarging the whole drilled surface.

Counter sinking : The operation of enlarging a hole in a conical manner to fit a screw in that position.

Q. 922. What is the difference between mechanisation and automation and rationalisation ?

Ans. Mechanisation replaces the muscle power of labour but not the labour itself. In automation, all the aspects of manufacturing are done by computer and human contribution is reduced to minimum.

Rationalisation refers to doing things on a scientific and rational basis.

Q. 923. Write two major advantages of robots in manufacturing.

- Ans.** (i) Robots relieve human beings from the burden of attending to dirty and dangerous tasks.
 (ii) Robots produces products of better quality because they are more predictable and perform the same operations precisely and repeatedly without fatigue.

Q. 924. What are the guiding principles to decide the type of plant layout ?

Ans. Minimum travel for men and materials, sequential order of machines, effective utilisation of space, integrated and compact layout, safety and satisfaction, flexibility, and minimum investment.

Q. 925. Define metal forming process ?

Ans. It is a process of forming the metal to the required shape and size without removing any portion of the metal.

Q. 926. How is a Metal tumbler made ?

Ans. By deep drawing process.

Q. 927. Define spinning.

Ans. Spinning is the process at shaping thin sheets to the required shape by pressing them against a form with blunt or hand tools by applying localised pressures.

Q. 928. Name the two systems used in metal cutting to designate the tool shape ?

- Ans.** 1. American Standard Association (ASA)
 2. Orthogonal rake system.

Q. 929. What is the importance of Nose radius ?

Ans. Nose radius is favourable to long tool life and good surface finish. A sharp point on the end of a tool is highly stressed, short lived and leaves a groove in the path of cut.

Q. 930. What are the first and last elements of tool signatures ?

Ans. Back rake angle and nose radius.

Q. 931. In straight polarity, to which terminal the electrode is connected ?

Ans. Negative.

Q. 932. Which welding set will you select for welding both ferrous and non ferrous materials.

Ans. D.C. generator set.

Q. 933. Which welding process is a combination of arc welding and gas welding processes ?

Ans. Atomic hydrogen welding.

Q. 934. Differentiate capstan lathe from turret lathe.

Ans.	Capastan lathe	Turret lathe
1.	It is a heavy duty semi - automatic lathe	It is a light duty semi - automatic lathe
2.	The turret head is mounted on a saddle. The saddle slides directly on the bed while machining	The turret head is mounted on a ram. The ram slides on the saddle. The saddle is clamped on the required position on the bed ways
3.	The construction provides rigidity to the tool while cutting. Hence, heavier cut can be taken.	This is a non - rigid construction. Hence only light cut can be taken
4.	Longer work piece can be machined.	Only shorter work piece can be machined.

Q. 935. 14. Mention two major differences between shaper and planer ?

Ans.	Shaper	Planer
(a)	The cutting tool reciprocates	Work reciprocates
(b)	The work is stationary	Tool is stationary
(c)	Meant for small work pieces	Meant for large work pieces
(d)	Only lighter cut can be taken	Heavy cuts can be taken
(e)	Tools are smaller in size	Tools are bigger in size

Q. 936. Differentiate between drilling and reaming ?

Ans.	Drilling	Reaming
(a)	It is the operation of initiating hole	Reaming is the operation of finishing and sizing a drilled/bored hole
(b)	It can be done at relatively high speeds	It should be done only at slow speeds
(c)	Larger chips are produced	Less chips are produced
(d)	Drill has only two flutes	Reamer has more than 4 flutes
(e)	Drill has chisel edge	Reamer has a bevel edge

Q. 937. Name the parts of broaching tool from one end to other

1. Follower rest
2. Rear pilot
3. Roughing teeth
4. Semi finishing teeth
5. Finishing teeth
6. Front pilot
7. Pull end

Q. 938. For what purpose chills are used in moulds ?

Ans. Chills are used to achieve directional solidification.

Q. 939. Helix angle of fast helix drill is normally ?

Ans. 5°.

Q. 940. In a typical metal cutting operation, using a cutting tool of positive rake $\gamma = 10^\circ$, it was observed that the shear angle was 20° . The friction angle $\phi = ?$

$$\text{Ans. Shear angle} = \frac{\pi}{4} - \frac{\text{friction angle}}{2} + \frac{\text{rake angle}}{2}; \text{ or } 20^\circ = 45^\circ - \frac{\text{friction angle}}{2} + \frac{10^\circ}{2}$$

$$\therefore \text{friction angle} = 60^\circ.$$

Q. 941. During orthogonal cutting of M.S. with a 10° rake angle tool, the chip thickness ratio was obtained as 0.4. Shear angle = ?

$$\text{Ans. } \tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} ; \quad \phi = \tan^{-1} \left(\frac{0.4 \cos 10^\circ}{1 - 0.4 \sin 10^\circ} \right) \approx 23^\circ$$

Q. 942. In an NC machining operation, the tool is at (5, 4) and is to be moved from this point to point (7, 2) along a circular path with centre at (5, 2). The correct G and M code for this motion is ?

Ans. NO 10 G 02 X 7.0 Y 2.0 I 5.0 J 2.0.

Q. 943. Resistance spot welding is performed on two plates of 1.5 mm thickness with 6 mm diameter electrode, using 15000 A current for a time duration of 0.25 sec. Assuming the interface resistance to be 0.0001Ω , the heat generated to form the weld is ?

$$\text{Ans. Heat} = I^2 R t = 15000^2 \times 0.0001 \times 0.25 = 5625 \text{ W sec.}$$

Q. 944. What is tumbler gear mechanism ?

Ans. Tumbler gear mechanism is a mechanism consisting of number of different sized gears keyed to the driving shaft in the form of cone and is used to give the desired direction of motion of the lathe spindle.

Q. 945. What is spring winding ?

Ans. Spring winding is the process of making coiled spring by passing a wire around a mandrel which is revolved on a chuck or between centres.

Q. 946. What is conicity ?

Ans. The ratio of the difference in diameter of the taper to its length is termed conicity.

Q. 947. What happens to impurities in centrifugal casting ?

Ans. They get collected at the centre of the casting.

Q. 948. What happens to ductility of a material with work hardening ?

Ans. It decreases.

Q. 949. When a built up edge is formed while machining ?

Ans. While machining ductile materials at high speed.

Q. 950. The height of a downsprue is 175 mm and its cross-sectional area at base is 200 mm^2 . Assuming no losses, how much time will be taken to fill a mould volume of 10^6 mm^3 volume ?

Ans. Volume of cavity = time \times area of sprue \times velocity

$$\text{or time} = \frac{10^6}{200 \times \sqrt{2} \times 9.81 \times 175 \times 1000} = 2.67 \text{ sec.}$$

Q. 951. A 3-2-1 method of location in a jig/fixture would collectively restrict the workpiece in n degrees of freedom. Value of n = ?

Ans. 9.

Q. 952. Which conventional machining process consumes maximum specific energy ?

Ans. Grinding.

Q. 953. How the cutting power consumption in turning can be significantly reduced ?

Ans. By increasing the rake angle of the tool.

Q. 954. Which method of milling would you recommend for peripheral milling with carbide tooth cutters and why ?

Ans. Down-cut milling is recommended because the radial force on cutter is very high initially in case of up-cut milling which causes rapid wear of cutter edges and has the effect of work

hardening the surface ? In down-cut milling the radial force increases gradually and is constant most of the time and thus cutter life with brittle teeth improves considerably.

Q. 955. Where the maximum chip thickness occurs in up-cut and down-cut milling ? What is the relationship between mean chip thickness (t_{mean}), feed per tooth (f_t), depth of cut (a_e) and cutter diameter (D).

Ans. In up-cut milling, maximum chip thickness occurs near the end of cut and in down-cut milling, maximum chip thickness occurs near the start of cut. Desired relationship is

$$t_{mean} = f_t \sqrt{\frac{a_e}{D}}$$

Q. 956. What type of chips are produced in plain milling of mild steel plate ?

Ans. Continuous chips without built up edge.

Q. 957. On which factor the cutting force in punching and blanking operation mainly depends ?

Ans. On shear strength of metal.

Q. 958. In which milling process, the value of tangential force and work done in cutting the chip are higher ?

Ans. In up-cut milling

Q. 959. In milling process, how the arbor torque can be smoothed ?

Ans. Arbor torque can be smoothed by increasing number of teeth, using higher spiral angle of teeth, using higher cutting depth.

Q. 960. If feed per tooth is doubled in a milling process, how the height of tooth marks vary ?

Ans. $h \propto f_t^2$

\therefore height of tooth marks will be four times if f_t is doubled.

Q. 961. A workpiece is finished using two tools having side cutting angles ψ of 25° and 30° and end cutting edge angle γ of 5° and 7° respectively. All other factors remaining same, which tool produces better finish ?

Ans. Max. height of unevenness (h) = $\frac{\text{feed}}{\tan \psi + \cos \gamma}$

\therefore For first tool $h_1 = \frac{f}{\tan 25^\circ + \cos 5^\circ} = 0.021f$; and for tool 2, $h_2 = \frac{f}{\tan 30^\circ + \cos 7^\circ} = 0.0286f$

Since h_1 is smaller than h_2 , tool 1 produces better finish.

Q. 962. What is chisel edge angle ?

Ans. Chisel edge angle is the angle between the chisel edge and the cutting lip as viewed from the end of the drill.

Q. 963. What are webs in a twist drill ?

Ans. Webs are the metal column in the drill which separates the flutes.

Q. 964. In ultrasonic machining process, if the mean grain diameter of abrasive material is increased, how it will affect material removal rate ?

Ans. It will increase.

Q. 965. Which factors determine the selection of electrolyte for electrochemical machining process ?

Ans. Electrolyte should be chemically stable and have high electrical conductivity.

Q. 966. For what type of material the material removal rate will be higher in ultrasonic machining process ?

Ans. Lower toughness.

Q. 967. The material is removed in ECM due to ?

Ans. Ion displacement.

Q. 968. In EDM process, what is the material of tool ?

Ans. Copper.

Q. 969. What is the use of trip dogs in a planer ?

Ans. The length end position of the stroke is adjusted by adjusting the position of trip dogs.

Q. 970. What are feed movements available in the slotter ?

Ans. 1. Longitudinal feed 2. Cross feed 3. Circular feed.

Q. 971. What are the basic operations performed in a slotter ?

Ans. The different operations done in slotter are :

1. Machining grooves 2. Machining cylindrical surface 3. Machining irregular profiles.

Q. 972. Name the angle between the land and face.

Ans. Relief angle.

Q. 973. Name the included angle between the land and cutting edges.

Ans. Lip angle.

Q. 974. It is required to produce a conical shape of 1.5 mm thickness with half cone angle of 30° by spinning process. What should be the thickness of blank for this purpose ?

Ans. 3 mm.

Q. 975. In which type of milling process the surface finish is better and tool life is longer ?

Ans. down milling.

Q. 976. In which material removal process, the tool need not be harder than workpiece ?

Ans. EDM process.

Q. 977. In which nonconventional process of machining, the job need not be good conductor of electricity ?

Ans. Ultrasonic machining.

Q. 978. Distinguish between brazing and soldering ?

Ans.	Brazing	Soldering
(a)	High melting point alloys are used	Low melting point alloys are used
(b)	The filler metal is known as spelter	Filler metal is known as solder
(c)	Strength of joint is high	Strength of joint is relatively low
(d)	Joining of dissimilar metals pipe and fittings	Mainly used for electrical connections
(e)	Process is done below the melting point of filler metal.	Process is done at melting point of filler metal.

Q. 979. How a slotter differs from shaper ?

Ans.	Slotter	Shaper
(a)	Ram reciprocates vertically	Ram reciprocates horizontally
(b)	It has a circular table	It has a rectangular table
(c)	Suited for machining internal surfaces	Suited for machining external surfaces
(d)	Table can take less load	Table can take much load

Q. 980. What is an arbor ?

An arbor is an accurately machined shaft for holding and driving the arbor type cutter. It is tapered at one end to fit the spindle nose and has two slots to fit the nose keys for locating and driving it.

Q. 981. Why uniform ramming is considered desirable in green sand moulding process ?

Ans. Uniform ramming results in greater dimensional stability of a casting.

Q. 982. What is the characteristic of centrifugally cast components ?

Ans. These have fine grain structure with high density.

Q. 983. What happens to specific energy in grinding when metal removal rate is increased by increase in work speed or depth of cut (increase in chip thickness) ?

Ans. Specific energy falls.

Q. 984. What is the difference between dressing and trueing of a grinding wheel ?

Ans. Dressing is the process used to clear the cutting surface of the grinding wheel of any dull grits and embedded swarf in order to improve the cutting action. Trueing is the process employed to bring the wheel to the required geometric shape and also to restore the cutting action of a worn wheel.

Q. 985. Whether hard grade or softer grade is required for internal grinding than external grinding ?

Ans. Softer grades of wheel are required for internal grinding than for external grinding.

Q. 986. What are the two principal economic advantages of grinder over other methods of metal machining for finishing ?

Ans. (i) Close tolerances and fine finish due to large number of very small chips cut.

(ii) High work speed and large number of cutting edges presented to the work.

Q. 987. A grinding wheel is specified as A 24 K 7V. What does it indicate ?

Ans. A — aluminium oxide grains, 24 — grain size (coarse), K — grade (Medium), 7 — Structure (medium), V — bond (vitrified).

Q. 988. What are the advantages of collet chucks ?

Ans.

1. Proper centering of bar is ensured	2. Suitable for Multi spindle machines
3. Simple in construction	4. It does not leave mark on the work piece.

Q. 989. What is follower rest ?

Ans. For slender work a travelling or follower rest is used. This fits on the lathe - saddle and travels to and fro with it. By this means support is constantly provided at the position of cut. Thus the work piece being turned is rigidly held against the tool.

Q. 990. What is the meaning of the term sensitive drill press ?

Ans. A sensitive drilling press is a light, simple, bench type machine for light duty working with infinite speed ratio.

Q. 991. What will be the value of current required for resistance spot welding of 1.5 mm thick steel sheet ?

Ans. 10,000 A.

Q. 992. What kind of penetration can be expected in d.c. welding with straight polarity, i.e. electrode made negative ?

Ans. lesser.

Q. 993. Which arc welding processes does not use consumable electrode ?

Ans. GTAW.

Q. 994. A number of cold rolling passes are required in a two - high rolling mill to reduce the thickness of a plate from 50 mm to 25 mm. The roll diameter is 700 mm and the coefficient of friction at the roll-work interface is 0.1. Draft in each pass is to be same and there are no front and back tensions. Determine the draft in each pass and the number of passes required ?

Ans. Draft in one pass = $\mu^2 R = 0.1^2 \times 350 = 3.5$ mm.

No. of passes = $\frac{50 - 25}{3.5} \simeq 7$ passes.

Q. 995. Why carburised machine components have high endurance limit ?

Ans. In carburised machine components, the process of carburisation introduces a compressive layer on the surface and thus endurance limit is increased.

Q. 996. What do you understand by centre line feeding (CFR) resistance ? For what value of CFR, the feeding is considered difficult ?

Ans. The difficulty of feeding a given alloy in a mould is expressed by CFR. It is the ratio of time interval between start and end of freezing at centre line to the total solidification time of casting. If CFR > 70%, then feeding is considered to be difficult.

Q. 997. If volume to surface area of one riser is 9 and of another riser it is 6, then what will be the ratio of their solidification times ?

Ans. 2.25 [solidification time $\propto (V/A)^2$].

Q. 998. What are the uses of runner and riser ?

Ans. Runner — To pour the molten metal into mould cavity

Riser — To show the level of molten metal and to remove flux and feed metal during solidification.

Q. 999. What is built up edge ?

Ans. Built up edge is a stagnant mass of chip material which welds to the tool face and occasionally breaks loose. A part is carried with chip flow and a part is deposited on the work surface.

Q. 1000. What do the CVD and PVD processes denote in relation to manufacture of coated cemented carbide and what is the temperature involved ?

Ans. CVD is chemical vapour deposition process in which inserts are heated to about 1000°C. PVD is physical vapour deposition technique which uses 500°C temperature.

Q. 1001. What are the essential characteristics of HSS and cemented carbides ?

Ans. HSS is tough and cemented carbide has high wear resistance.

Q. 1002. What are the two basic types of ceramics ?

Ans. Al_2O_3 and Si_3N_4

Q. 1003. What are the essential characteristics of CBN and PCD cutting tool materials ?

Ans. CBN (cubic boron nitride) is extremely hard, has high hardness upto 2000°C, excellent basic wear resistance, good chemical stability. PCD (Polycrystalline diamond) is used for turning and milling abrasive silicon-aluminium alloys when surface finish and accuracy are the criteria. It is brittle, cutting temperature should not exceed 600°C, can not be used for ferrous and high tensile workpieces.

Q. 1004. What parameters influence the tool life ?

Ans. 1. Tool material 2. Work material 3. Speed, feed and depth of cut 4. Tool geometry work system 5. Cutting fluid 6. Built up edge 7. Vibration behaviour of the machine tool.

Q. 1005. Mention the function of intermediate stage in a generalised measurement system.

Ans. (i) Amplify signal without affecting its waveform

(ii) Remove unwanted noise signals that tend to obscure the input

(iii) Capable of doing other conditioning like differentiation/integration, A/D conversion etc.

Q. 1006. What are strain gauge rosettes and what are its applications ?

Ans. The arrangement of strain gauges in the shape of a rose is referred to as a strain gauge rosette. It is usually used for measurement of strain in both transverse and longitudinal direction.

Q. 1007. For what purpose Mcleod gauge is used ?

Ans. Mcleod gauge is used for low pressure measurement.

Q. 1008. What is a signal flow graph ?

Ans. A signal flow graph of a system is a graphical model in which nodes represent the system variables and directed branches between the nodes represent relationship between the variables. In a signal flow graph, a forward path originates from the input node and terminates at output node without encountering any node more than once.

Q. 1009. Define the term stability of a feed back control system ?

Ans. A system is said to be stable if the output of a system after fluctuations, variations or oscillations, settles at a reasonable value for any change in input.

Q. 1010. What is meant by precision ?

Ans. Precision is defined as the ability of instrument to reproduce a certain set of readings within a given accuracy.

Q. 1011. What is meant by relative stability ?

Ans. If the system is found to be stable, then it is necessary to know the stable strength or degree of stability which is called relative stability. Phase margin and gain margins are the measures of relative stability.

Q. 1012. What is meant by accuracy ?

Ans. Accuracy of a measurement system is a closeness of the instrument output to the true value of measured quantity.

Q. 1013. What for pyrometers are used ? What are the types of pyrometers ?

Ans. Pyrometers are used to measure high temperatures (more than 650°C). Two types in common use are :

(i) Total radiation pyrometer **(ii)** Optical pyrometer (Disappearing filament type).

Q. 1014. What is meant by optical torsion meter ?

Ans. Torque is measured by means of measuring relative angular displacement of two graduated transparent sector discs mounted on the shaft at a convenient distance : When the torque is applied to the shaft the discs move relative to each other corresponding to the angular twist of the shaft and this displacement is read through the eyepiece of an optical system, whose light source illuminates the transparent sector of the discs.

Q. 1015. Define transducer ?

Ans. Transducer is an element which converts the signal from one physical form to another without changing the information content of the signal.

Q. 1016. Give some properties of errors ?

Ans. (i) Errors give the difference between the measured value and the true value
(ii) Accuracy of a measurement system is measured in terms of error
(iii) A study of error helps in finding the reliability of the results.

Q. 1017. What for pycnometer is used ?

Ans. Pycnometer is used to measure specific gravity of the liquid.

Q. 1018. How many types of bonded strain gauges used ?

Ans. (a) Fine wire strain gauge (b) Metal foil strain gauge (c) Piezo resistive gauge.

Q. 1019. What is PID controller ?

Ans. A suitable combination of three basic modes — proportional, integral and derivative (PID) used to improve all aspects of system performance is called PID controller. The characteristics of three modes of control are :

Proportional controller	—	Stabilises gain but produces a steady state error.
Integral controller	—	Eliminates steady state error
Derivative controller	—	Reduces rate of change of error

Q. 1020. Name various functional elements of an instrumental system ?

Ans. (1) Primary sensing element (2) Variable conversion (or) transducer element
(3) Variable manipulation element (4) Data transmission element
(5) Data processing element (6) Data presentation element
(7) Data storage and playback element.

Q. 1021. What is the use of a hot-wire anemometer ?

Ans. It is used to measure the flow rate and used in study of varying flow conditions.

Q. 1022. Name the three stages of a generalised measuring system.

Ans. (i) Sensing and converting the input to a convenient and practicable form.
(ii) Processing/manipulating the measured variable.
(iii) Presenting the processed measured variable in quantitative form.

Q. 1023. What is the function of an intermediate modifying system ?

Ans. Various functions of an intermediate modifying system are

(1) Amplification	(2) Modification (modulation)
(3) Data Processing and	(4) Data transmission.

Q. 1024. What is static pressure ? How is it measured.

Ans. The pressure caused on the walls of a pipe due to a fluid at rest inside the pipe or due to the flow of a fluid parallel to walls of the pipe is called static pressure. This static pressure is measured by inserting a pressure measuring tube into the pipe carrying the fluid so that the tube is at right angle to the fluid flow path.

Q. 1025. What are the requirements of a control system ?

Ans. Stability, accuracy and speed of response are the three requirements of control system.

Q. 1026. What is order of the system.

Ans. The order of the system is the order of the highest derivative of the ordinary differential equation with constant coefficients which defines the system mathematically.

Q. 1027. Define rise time and settling time :

Ans. The rise time is defined as the time required for the response to rise from 10% to 90% or 5% to 95% or 0% to 100% of the final value.

Settling time : The settling time is the time required for the system response to reach and stay within a specified range about final value.

Q. 1028. What is Bode plot ?

Ans. Bode plot is a logarithmic plot used to represent transfer functions. The Bode plot consists of two plots namely.

- (i) The plot of magnitude in db (on linear scale) vs. frequency ω (on log scale)
- (ii) The plot of phase angle in degrees (on linear scale) vs. frequency ω (on log scale)

Q. 1029. What are the characteristics of precision ?

Ans. (i) If a number of measurements are made on same true value, the degree of closeness of these measurements gives precision

- (ii) It is a measure of the degree of repeatability or reproducibility of the measuring system.

Q. 1030. What is meant by loading ?

Ans. During the act of measurement the measuring instrument takes energy from the signal source or measured medium and thus the signal source is altered. This effect is called loading.

Q. 1031. Give two uses of Bode plots.

- (i) They are the logarithmic plots used to represent transfer functions
- (ii) They are used in the calculation of gain margin and phase margin.

Q. 1032. What is the function of a transducer element ?

Ans. The function of a transducer element is to sense and convert the desired input into a more convenient and practicable form to be handled by measurement system.

Q. 1033. Define primary and secondary transducers ?

Ans. A primary transducer senses a physical phenomena and converts it to an analogous output. The analogous output is then converted into an electrical signal by secondary transducer.

Q. 1034. What are seismic instruments ?

Ans. Seismic instruments are absolute motion measurement devices to indicate or record absolute displacement, velocity and acceleration of a vibrating body.

Q. 1035. Give three active and passive transducers ?

Ans.	Active transducers	Passive transducers
1.	Thermocouples and Thermopiles	Resistive transducers
2.	Moving coil generators	Inductive transducers
3.	Photovoltaic cells	Capacitive transducers

Q. 1036. What is a Thermopile ?

Ans. It is the arrangement of several thermocouples in series with all measuring junctions at one temperature and all reference junctions at another in order to achieve high sensitivity.

Q. 1037. What are the energy storing elements in mechanical, electrical, thermal, hydraulic and pneumatic systems ?

Ans.	Mechanical	:	Mass and Springs
	Electrical	:	Inductor and capacitor
	Thermal	:	Thermal Capacitance
	Hydraulic	:	Hydraulic inertia and Capacitance
	Pneumatic	:	Pneumatic inertia and Capacitance.

Q. 1038. Give the reasons for plotting averages of samples instead of individual values in \bar{X} control chart. (UPSC CES 1999)

Ans. It has been observed that for averages of subgroups the distribution is normal even though population is not normal. The control limits are determined assuming normal distribution.

Q. 1039. Explain the difference between roughness and waviness. (UPSC CES 1999)

Ans. Surface roughness concerns all those irregularities which form surface relief and which are conventionally defined within the area where deviations of form and waviness are eliminated. Primary texture roughness is caused due to irregularities in the surface roughness resulting from the inherent action of the production process (including transverse feed marks). Waviness results from machine or work deflection, vibrations, chatter, heat treatment or warping strains.

Q. 1040. Explain the term strategic planning.

Ans. A planning process that involves taking information from the environment, deciding on long-range goals, selecting activities to achieve those goals, and allocating resources to those activities.

Q. 1041. What do you understand by quality funnel principle ?

Ans. A principle in quality control which states that the cost of poor quality increases as the output passes progressively farther through the transformation process. The implication is that the cost of poor quality is minimised if detected and corrected in input stage.

Q. 1042. Describe nominal group technique (NGT) ?

Ans. NGT is a technique used to achieve a group decision through a combination of both verbal and nonverbal stages. It typically takes the form of a structured group meeting that follows specific procedures and culminates in a group decision based on the mathematical calculation of independent prioritised voting.

Q. 1043. What impact will be made by adoption of TQM in organisations ?

Ans. — Lower costs and improved quality, *i.e.* increased product reliability, on-time delivery, less errors and lead times.

— Increased customer satisfaction and lesser complaints

— Increased employee satisfaction.

Q. 1044. Define five-step quality improvement programme.

Ans. (i) define quality characteristics (ii) establish quality standards
(iii) develop quality review programme (iv) build quality commitment
(v) design and use quality measurements and a reporting system.

Q. 1045. For studying behavioural sciences, one needs to study disciplines of psychology, sociology, and anthropology. Describe them in brief.

Ans. Psychology is the study of human behaviour. Productivity, can be improved by understanding psychology and use of techniques like self-motivation, participation, quality of work, life, new organisational designs, team building, job enrichment, etc.

Sociology attempts to isolate, define, and describe human behaviour in groups. It strives to develop laws and generalisations about human nature, social interaction, culture, and social organisation.

Anthropology examines the learned behaviours of people, how they behave, the priority of needs they attempt to satisfy, and the means they choose to satisfy them, etc.

Q. 1046. What are the three managerial tasks for managers ? What are the challenges for them ?

Ans. (i) Managing work and organisations (ii) Managing people
(iii) Managing production and operations.

A manager needs wide knowledge to (i) plan, (ii) organise, (iii) lead, and (iv) control. They can rely primarily on information based on the classical approach to manage work and organisations. To manage people, they need behavioural information. To manage operations, managers must have a management science perspective.

Q. 1047. Explain the difference between production and productivity ?

Ans. Production refers to total output while productivity refers to the output relative to the inputs. Productivity is the ratio of quantity of goods and services produced to the amount of resources used.

Q. 1048. In inventory control techniques, various classifications are ABC, HML, VED, SDE, FSN, EOQ, JIT. What these abbreviations stand for ?

Ans. ABC categorises inventory into three groups A, B, and C according to the potential amount to be controlled annually.

HNL — High, medium and low as per unit value, VED — Vital part, Essential part and not so essential
SDE — Scarce, difficult, easy to acquire items, FSN — Fast moving, slow moving and non proving parts
EOQ — Economic order quality, JIT — Just in time.

Q. 1049. Explain the concept of quality circle.

Ans. Quality circle is a small group that voluntarily performs quality control activities within the shop, where its members work in small group carrying out its work continuously as part of a company-wide programme of quality control, self development, mutual development, flow-control and improvement within workshop. By engaging in quality circle activities, the circle members gain valuable experience in communication with colleagues, working together to solve problems and sharing their findings, not only amongst themselves, but with other circles at other companies.

Q. 1050. What do you understand by operating leverage and how uncertainty in forecast of sales affects decision for operating leverage ?

Ans. Operating leverage is a measure of relationship between a firm's annual cost and its annual sales. If high percentage of firm's total costs are fixed, it has high degree of operating leverage and its break even point is achieved at higher level of production. Thus if sales forecast are uncertain, we should adopt lower operating leverage in the firm.

Q. 1051. Explain the difference between operation process chart and flow process chart.

Ans. Operation process chart is a graphical representation of the points at which materials are introduced into the process, sequence of inspections and other operations. It enables analysis of time required, location, etc.

Flow process chart is a graphical representation of all operations, transportations, inspections, delays and storages during a process. It enables analysis of time required and distances travelled, etc.

Q. 1052. What are the essential characteristics of operations research ?

Ans. Operations research refers to the use of mathematical techniques to solve management problems. It approaches problem solving and decision making from the total systems perspective. It draws on techniques from varied disciplines. Its primary focus is on decision making and uses computers extensively. It does not experiment with the system but constructs a model of the system on which experiments are conducted.

Q. 1053. In past companies could manage by focusing management efforts on managing day to day affairs efficiently. However today, adapting to changing environments has become essential for success. What is the role of strategic management for this ?

Ans. Strategic management focusses on scanning of external and internal environments, formulate strategies relating to such changes, analysis of opportunities and threats or constraints, formulation of strategies matching with strengths and weaknesses of organisation, evaluate and control activities with a view to help the organisation to achieve its objectives in improved, effective, efficient and flexible manner.

Q. 1054. Explain the difference between corporate strategy and operations strategy.

Ans. Corporate strategy is long range goal and is formulated by top level management to oversee the interests and operations of an organisation such as — to continuously innovate in all businesses with right technology, relentlessly cut costs and focus on overseas markets. Operations strategy are derived corporate objectives. These provide the road map for long-range game plan for production of the firm's goods and services.

Q. 1055. Explain briefly the Delphi method used for forecasts ?

Ans. It draws on a pool of experts, both from within and outside the organisation. Each expert is conversant with his area and with all aspects of the issue. Each expert is allowed to make independent predictions. Coordinator edits and clarifies their statements. Then coordinator provides a series of written questions to experts, that include feedback supplied by other experts. The process is repeated six to seven times till consensus is obtained.

Q. 1056. What are the five process technologies and for what purpose each is suitable ?

Ans. Five process technologies are

(i) **Job shop technology.** It is suitable for a variety of custom designed products in small volume.

(ii) **Batch technology.** It is suitable for a variety of products in varying volumes.

(iii) **Assembly line technology.** It is suitable for a narrow range of standardised products in high volume.

(iv) **Continuous flow technology.** It is suitable for producing a continuous stream of products on continuous flow (oil refinery, chemical plants, etc.)

(v) **Project technology.** It is suitable for tailor made products, each unique for each customer.

Q. 1057. What do you understand by product-process mix ?

Ans. Product-process mix helps us analyse and determine production operations. With changes in products, market requirements and competition, the equipments, processes, procedures and human resources also need to be changed. Process changes are required to accommodate process life cycles otherwise these become incompatible and uncompetitive.

Q. 1058. What do you understand by the term - Mechatronics ?

Ans. It is the integration of a number of discipline such as mechanics, electronics, electrical, computer, control, and software engineering using microelectronics to control mechanical devices. It is applied to production design, monitoring, and control with the objective of achieving high quality products at optimal running conditions. To achieve this, mechatronics integrates advances in semiconductor technology, computer and communications technology, robotics, computer vision, and intelligent neuro-fuzzy technology. It acts as a tool in facilitating companies to ensure that their product will fulfill consumers desired performance and quality requirements.

Q. 1059. What do you understand by surface integrity ?

Ans. Surface integrity describes all the conditions existing on or at the surface of a workpiece. It is concerned with surface topography (roughness, lay or texture) of outermost layer, and surface metallurgy (nature of the altered layer below the surface).

Q. 1060. Which are the five distinct parameters to define the surface topography ?

Ans. RMS, CLA, peak to trough roughness, spacing, and shape factor.

Q. 1061. What are the more recent ways of defining surface roughness ?

Ans. Statistical evaluation of profile, probability density and distribution function, auto-correlation functions and power spectral density function.

Q. 1062. If demand for an item is doubled and the ordering cost is halved, then the economic order quantity will _____ ?

Ans. It will remain unchanged because $EOQ = \sqrt{\frac{2 \times \text{ordering cost} \times \text{demand}}{\text{unit holding cost}}}$

Q. 1063. In order to attain high process capability on a machine tool, its structure is made _____ ?

Ans. rigid.

Q. 1064. Can slip gauges be calibrated by external micrometer ?

Ans. No. Accuracy of calibration source should be one order higher than the device to be calibrated.

Q. 1065. What type of fit will result when shaft of $20^{+0.05}_{-0.15}$ mm diameter is assembled with a hole $20^{+0.20}_{+0.10}$ mm diameter ?

Ans. Clearance fit.

Q. 1066. An automat is producing cylindrical pins of 10 mm diameter and has process capability of 0.012 mm. Every 15 minutes, a sample of 9 pins are taken and their diameters measured for quality control. What are limits for the control chart ?

Ans. $3\sigma = 0.012, n = 9$

$\therefore UCL = 10 + \frac{0.012}{\sqrt{9}} = 10.004$; and $LCL = 10 - 0.004 = 9.996$.

Q. 1067. The manufacturing area of a plant is divided into four quadrants. Four machines have to be located, one in each quadrant. The total number of possible layouts is ?

Ans. $4 \times 3 \times 2 = 24$.

Q. 1068. What do you understand when it is specified that the failure load of a bolt is 20000 ± 200 N ?

Ans. It implies that no bolt is weaker than 19800 N and stronger than 20200 N.

Q. 1069. If 20% managers are technocrats, the probability that a random committee of 5 managers consists of exactly 2 technocrats is _____ ?

Ans. Probability of technocrat manager $p = \frac{20}{100} = 0.2$

Probability of non-technocrat manager $q = 0.8$

Probability that a random committee of 5 members has exactly 2 technocrats is

$${}^5C_2 p^2 q^3 = \frac{5 \times 4}{1 \times 2} (0.2)^2 (0.8)^3 = 0.2048.$$

Q. 1070. What are eutectic or phase changing salts and what can be their use ?

Ans. These salts store large quantities of heat in a relatively small volume. These melt when heated and release heat when they cool and crystallise. They can be used to produce power from solar energy.

Q. 1071. How much energy is radiated on earth by sun on bright sunny day ?

Ans. 1 kW/m^2

Q. 1072. How much energy sun gives on earth compared to world-wide power demand of all needs of civilisation ?

Ans. 1000 times.

Q. 1073. What is the special feature of renewable energy sources ?

Ans. These can not be exhausted.

Q. 1074. Explain difference between beam radiation and diffuse radiation.

Ans. Solar radiation that has not been absorbed or scattered and reaches the earth directly from sun is called beam radiation. It produces a shadow when interrupted by an opaque object. Diffuse radiation is that solar radiation which is received from sun after its direction has been changed by reflection and scattering by the atmosphere.

Q. 1075. What wave-lengths are useful for terrestrial solar applications ?

Ans. Wave-lengths between 0.29 and 2.5 μm .

Q. 1076. What are pyrheliometers and pyranometer ?

Ans. Pyrheliometer is an instrument used to measure beam intensity as a function of incident angle, *i.e.* it measures beam radiation.

Pyranometer is an instrument used to measure total or global radiation over a hemispherical field of view.

Q. 1077. What is a fuel cell ?

Ans. A fuel cell is capable of generating an electric current by converting the chemical energy of a fuel directly into electrical energy.

Q. 1078. What are the main components of fuel cell ?

Ans. A fuel cell consists of positive and negative electrodes with an electrolyte between them. Fuel in suitable form is supplied to the negative electrode and oxygen (from air) to the positive electrode. Due to oxidation of fuel, chemical reaction provides the energy that is converted into electricity. Both fuel and oxygen are supplied from outside.

Q. 1079. What fuels are used in fuel cells ?

Ans. H_2 , N_2H_4 (hydrazine), hydrocarbons, and methanol.

Q. 1080. Why porous electrodes are used in fuel cells ?

Ans. Porous electrodes provide large number of sites where gas, electrolyte and electrode get in contact and electrochemical reactions occur at these sites. Usually finely divided platinum is deposited to expedite chemical reactions.

Q. 1081. Why 40% KOH solution is used as electrolyte in fuel cells ?

Ans. It has high electrical conductivity and is less corrosive than acids.

Q. 1082. How the output of fuel cell can be increased ?

Ans. By increasing gas pressure. Pressures upto 45 atmospheres and temperatures upto 300°C are in use.

Q. 1083. What do you understand by fossil fuel cells ?

Ans. Coal serves the primary energy source. Fuel processor converts fossil fuel into a hydrogen rich gas.

Q. 1084. What is the efficiency of fuel cells ?

Ans. Fuel cells have efficiency of the order of 70%.

Q. 1085. What is polarisation in fuel cells ?

Ans. In practical fuel cell the theoretical output voltage is not attained due to various factors. The difference between theoretical and actual voltage is referred to as polarisation.

Q. 1086. What are the various types of polarisations in fuel cells ?

Ans. (i) Activation or chemical polarisation due to activation energy barrier for the electron transfer process at the electrode.

(ii) Resistance polarisation which occurs due to internal resistance of electrodes, bulk electrolyte, interface contact etc. Its magnitude is high for high current density.

(iii) Concentration polarisation due to slow step in mass transport processes in cell, both on electrolyte side and gas side.

Q. 1087. How the polarisation can be minimised ?

Ans. By increasing temperature.

Q. 1088. What is the difference between fuel cell and battery ?

Ans. Fuel cell generates electrical energy by directly converting the chemical energy of fuel, whereas in battery the electrical energy is stored as chemical energy which can be recovered as electrical energy when it is discharged.

Q. 1089. State whether following statements are true for hydrogen as a fuel ?

(i) Hydrogen is superior to gasoline on both weight basis as well as on a volume basis.

Ans. False. Heating value of hydrogen gas is 12.1 MJ/m^3 against 38.3 MJ/m^3 for natural gas. But liquid hydrogen has heating value of 120 MJ/kg against 44 MJ/kg for gasoline. Thus hydrogen is superior to gasoline on weight basis and inferior on volume basis.

(ii) The flame speed of hydrogen burning in air is much greater than for natural gas.

Ans. True

(iii) Theoretically 2.8 kWhr of electrical energy is required to produce 1 m^3 of hydrogen gas by electrolysis but in actual practice 3.9 to 4.6 kWhr is needed to produce 1 m^3 of hydrogen. Thus η of electrolysis is roughly 60-70%.

Ans. True

(iv) Most electrolyzers operate with relatively high cell voltages between 1.8 and 2.2 volts and relatively modest current densities of 0.15 and 0.30 A/cm^2

Ans. True

Q. 1090. Explain in brief the thermochemical cycle for production of hydrogen.

Ans. In thermochemical cycle, a sequential chemical reaction occurs in which H_2 and O_2 are produced, water is consumed and all other chemical intermediates are recycled.

Q. 1091. What is hydrogasification ?

Ans. It is the direct reaction of H_2 with carbon of the coal to produce methane.

Q. 1092. Describe in brief the process of photo-electrolysis.

Ans. In photo electrolysis, a current is generated by exposing both electrodes to sunlight, one of electrodes being semiconductor and a catalyst being included.

Q. 1093. Under ideal conditions the time for an operation was 1 mm per piece. If performance rating of operator is 120 and 5% personal time is to be allowed, what will be normal and standard time in minutes per piece ?

$$\text{Ans. Normal time} = \frac{\text{Observed time}}{\text{Normal performance}} = \frac{1}{100/120} = 1.2 \text{ mts}$$

$$\text{Standard time} = \text{Normal time} \times \text{allowance} = 1.2 \times 1.05 = 1.26 \text{ mts.}$$

Q. 1094. What environment comprises of ? What is the role of environment in development of mankind ?

Ans. Environment comprises air, water, land, flora and fauna, forests etc. Environment provides essential and basic services, like — raw materials and inputs to support economic and developmental activities, absorption and recycling of waste products of society, and provision of essential life support systems and other functions essential for living organism.

Q. 1095. What is understood by biodiversity ?

Ans. Biodiversity refers to the existence of a wide range of flora and fauna.

Q. 1096. What is biological diversity ?

Ans. Biological diversity is the total variety of genetic strains, species and ecosystems.

Q. 1097. Out of C, H, F, and Cl, in refrigerant, which content has more effect on ozone layer depletion ?

Ans. Chlorine.

Q. 1098. Why is it essential to conserve biological diversity ?

Ans. All species deserve respect regardless of their use to humanity because they are all components of our life support system. Biological diversity also provides us with economic benefits and adds greatly to the quality of our lives. Ecological importance is being realised because of the economic utility of plant resources.

Q. 1099. Global environment degradation is a reality. What sort of environmental problems are encountered in developed and under developed countries ?

Ans. In developed countries, the concerns of development and economic growth coupled with advancement of scientific and technological development for augmenting the exploitation of natural resources are polluted air, water, land, flora and fauna which are interconnected, interrelated and interdependent. The environmental problems of developing countries are however on account of under-development, poverty and population growth exceeding the threshold limits of support systems.

Q. 1100. What major points are encompassed by sustainable development and on what issues it lays focus ?

Ans. Sustainable development encompasses (i) economic, (ii) social, and (iii) ecological points of views.

It focuses on (i) flow of income, (ii) stability of biophysical system, (iii) protection of biological diversity, (iv) maintenance of stability of social and cultural systems.

Q. 1101. Explain the difference between work, power and energy.

Ans. Work is done when a force is displaced by a distance. Its unit is Nm. Work done in causing angular motion θ of a body subjected to torque T is $T \cdot \theta$. Power is the rate of doing work. It is equal to force \times velocity or Torque \times angular speed and its unit is Nm/s or Watt (W).

The capacity to do the work is termed as energy. It is product of power and time. Its unit is kWh.

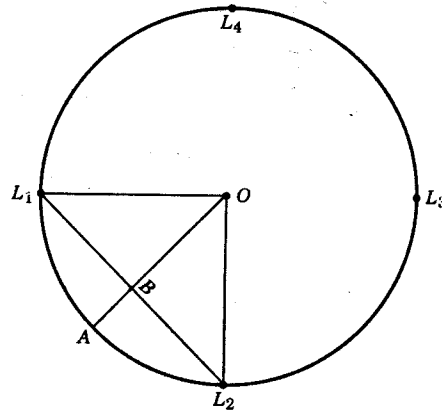
Q. 1102. An engine has a flywheel whose size needs to be reduced to half due to space limitation. Its average torque and angular acceleration are to remain unchanged, what should be new mass of flywheel ?

Ans. 4 times ($T = I \alpha = mk^2 \cdot \alpha$)

Q. 1103. A circular table of mass 25 kg and radius 1 m is supported on 4 legs symmetrically on its circumference. What weight will be able to topple it ?

Ans. 60 kg (At toppling point weight needs to be placed at A and reactions at L_3 and L_4 will be zero. Taking moments about plane L_1L_2 , $25 \times OB = W \times AB$)

$$\begin{aligned} \text{or } W &= 25 \times \frac{OB}{AB} = 25 \times \frac{\frac{1}{\sqrt{2}}}{1 - \frac{1}{\sqrt{2}}} \\ &= 25 \times \frac{1}{\sqrt{2} - 1} = \frac{25}{-0.414} = 60 \text{ kg} \end{aligned}$$



Q. 1104. A ball of mass 150 g is balled at a speed of 80 km/hr and is hit back at 130 km/hr. If force of blow on ball acts for 0.01s, the average force exerted by bat on ball will be ____ ?

Ans. 775 N

(Hint : $\frac{(130 + 80) 1000}{3600} \times \frac{150 \times 10^{-3}}{0.01} = \frac{210 \times 1000}{3600} \times \frac{.15}{.01} = 775 \text{ N}$)

Q. 1105. Fig. 1 shows a mass(m) supported through three pulleys. Assume pulleys have no mass and ignore the friction between cable and pulleys, Tension $T =$ _____ ?

Ans. $T = \frac{mg}{4}$ ($mg = 4T$)

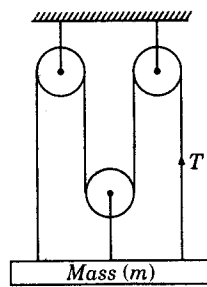


Fig. 1

Q. 1106. Fig. 2 shows a quick return mechanism with $O_1 A = 10 \text{ cm}$ and $O_1 O_2 = 20 \text{ cm}$. Crank $O_1 A$ rotates uniformly. Ratio of time for forward motion to return motion = ____ ?

Ans. 2 (Angle of crank at connecting rod at tangent to circle corresponding to start of forward and backward stroke = 60° ($\cos \theta = 10/20$))

\therefore Angles of forward and return stroke are 240° and 120° .

Q. 1107. Force F needed to support liquid of density ρ in Fig. 3 = ____ ?

Ans. $\rho g (h_1 + h_2) A$.

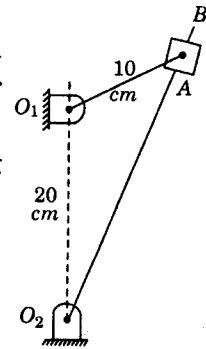


Fig. 2

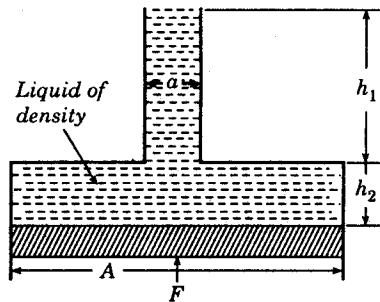


Fig. 3

Q. 1108. Pressure of water in a pipe is measured by a mercury manometer Fig. 4. For mercury rise of 10 mm, pressure $P =$ _____ ?

Ans. 1333 Pa ($P = \rho g h = 13,600 \times 9.81 \times \frac{10}{1000}$)

Q. 1109. For the loading shown in Fig. 5, reaction $R_B =$ _____ ?

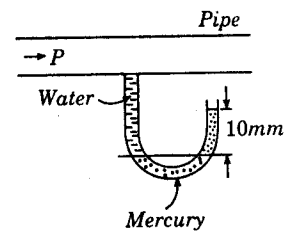


Fig. 4

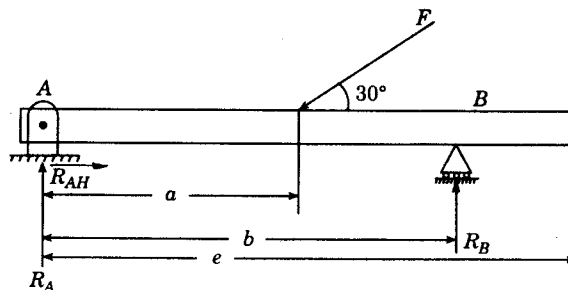


Fig. 5

Ans. $\frac{Fa}{2b}$

Taking moments about A, $(R_B \times b) - (F \sin 30^\circ \times a) = 0$

$\therefore R_B = \frac{Fa}{2b}$

Q. 1110. For gear drive in Fig. 6, the ratio of speed of first and last gear = _____ ?

Ans. 2

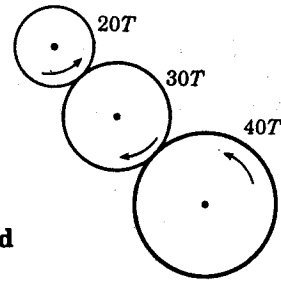


Fig. 6

Q. 1111. Fig. 7 shows a psychrometric chart. Name the lines x, y, AB, OC, OE, OF, OD, OH and OG.

Ans. x = Dry bulb temperature

y = specific humidity

AB = saturation line

OC = sensible heating

OE = isothermal humidification

OF = adiabatic saturation

OD = sensible cooling

OH = isothermal dehumidification

OG = chemical dehumidification.

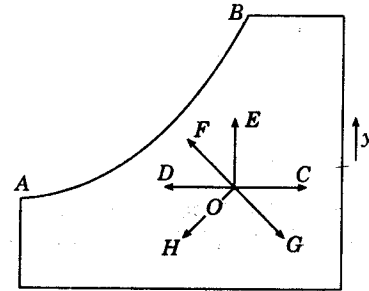


Fig. 7

Q. 1112. The maximum principal stress for stress loading in Fig. 8 is _____ ?

Ans. Max-principal stress = $\frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \sigma_{xy}^2}$
 $= \frac{\sigma + \sigma}{2} + \sqrt{\left(\frac{\sigma - \sigma}{2}\right)^2 + \sigma^2} = 2\sigma$

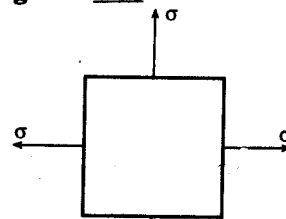


Fig. 8

Q. 1113. A thick cylinder is subjected to an internal pressure of 100 MPa and hoop stress on outer surface is found to be 400 MPa. The hoop stress on internal surface = _____ ?

Ans. $400 = \frac{2p R_i^2}{R_o^2 - R_i^2}$

or $\frac{400}{2 \times 100} = \frac{R_i^2}{R_o^2 - R_i^2} = \frac{1}{(R_o/R_i)^2 - 1}$

or $(R_o/R_i)^2 - 1 = 0.5$ and $(R_o/R_i)^2 = 1.5$

Hoop stress on internal surface = $\frac{p(R_o^2 + R_i^2)}{R_o^2 - R_i^2}$

$= p \left[\frac{(R_o/R_i)^2 + 1}{(R_o/R_i)^2 - 1} \right] = 100 \times \frac{2.5}{0.5} = 500 \text{ MPa.}$

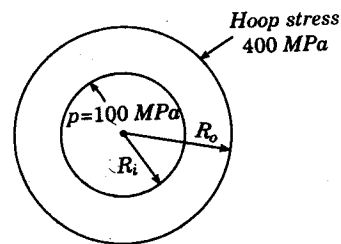


Fig. 9

Q. 1114. A rod AB, 1 m long, is slipping down in a corner. When rod makes angle of 60°, point A is sliding at 1 m/s. What will be the angular velocity of rod at this instant ?

Ans. 2 rad/s

(If velocity at A is 1 m/s, the velocity at B will be $\sqrt{3}$ m/s. Thus resultant speed of rod AB will be vector sum of V_A and V_B and this will be 2 m/sec. Angular speed of rod = $2/1 = 2$ rad/s.)

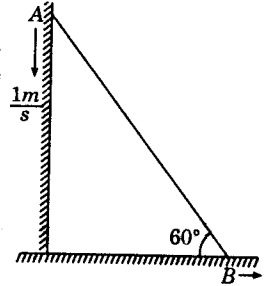


Fig. 10

Q. 1115. The combined stiffness of springs in Fig. 11 = ____ ?

Ans. 11/4 kN/m

(For springs in series $\frac{1}{K_s} = \frac{1}{1} + \frac{1}{3} = \frac{4}{3}$ and $K_s = \frac{3}{4}$

For springs in parallel,

$$K_s' = K_s + 2 = \frac{3}{4} + 2 = \frac{11}{4} \text{ kN/m}$$

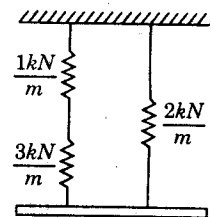


Fig. 11

Q. 1116. A solar engine receives 100 kJ heat at 100°C and rejects 80 kJ at 30°C. What is its efficiency ?

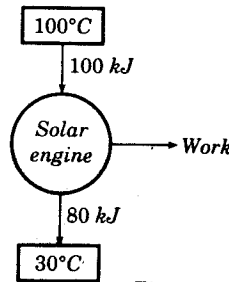


Fig. 12

Ans. 20% $\left(\eta = \frac{\text{Work output}}{\text{heat input}} = \frac{100 - 80}{100} \right)$

Q. 1117. Two engines coupled in series have efficiencies of 30% and 20% respectively. Overall combined $\eta =$ ____ ? (Refer Fig. 13)

Ans. 44%

$$\left(\begin{aligned} \eta_1 &= \frac{Q_1 - Q_2}{Q_1} = 0.3 & \text{or} & \frac{Q_2}{Q_1} = 0.7 \\ \eta_2 &= \frac{Q_2 - Q_3}{Q_2} = 0.2 & \text{or} & \frac{Q_3}{Q_2} = 0.8 \end{aligned} \right)$$

$$\eta_0 = \frac{Q_1 - Q_3}{Q_1} = \frac{\frac{Q_2}{0.7} - 0.8 Q_2}{\frac{Q_2}{0.7}} = 44\%$$

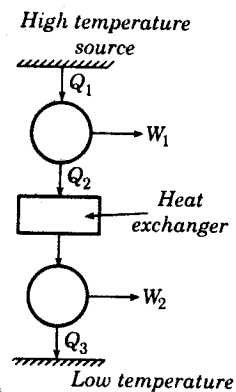


Fig. 13

Q. 1118. The efficiencies of various components in a thermal plant is shown in Fig. ____ . The overall plant η is ____ ? (Refer Fig. 14)

Ans. 34%

$$\text{(Cycle } \eta = \frac{Q - .56 Q}{Q} = 44\%,$$

Gen. Output = $0.92 \times 0.44 \times 0.94 \times 0.95 Q$
 and net output = $(1 - 0.06)$ Gen. output
 \therefore overall
 $\eta = 0.92 \times 0.94 \times 0.44 \times 0.95 \times 0.94 = 0.34$).

Q. 1119. Two bars AB and BC are connected by a frictionless hinge at B. The supports and loads are as shown in Fig. 15. Draw shear force and bending moment diagram for beam AC.

Ans. $R_B \times 4 = 100 \times 2 + 200 \times 1$

and $R_B = 100 \text{ kN}$ and $R_C = 200 \text{ kN}$

Since B is frictionless hinge, bending moment at B = 0. Consider beam AC in two parts as AB and BC.

Shear force diagram and bending moment diagrams for AB, BC and AC are shown in Fig. 16.

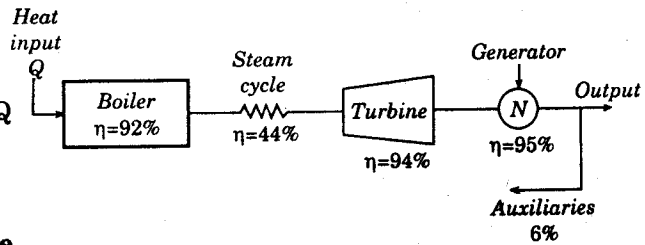


Fig. 14

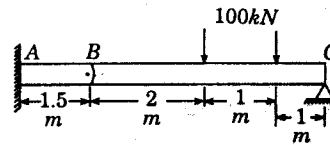


Fig. 15

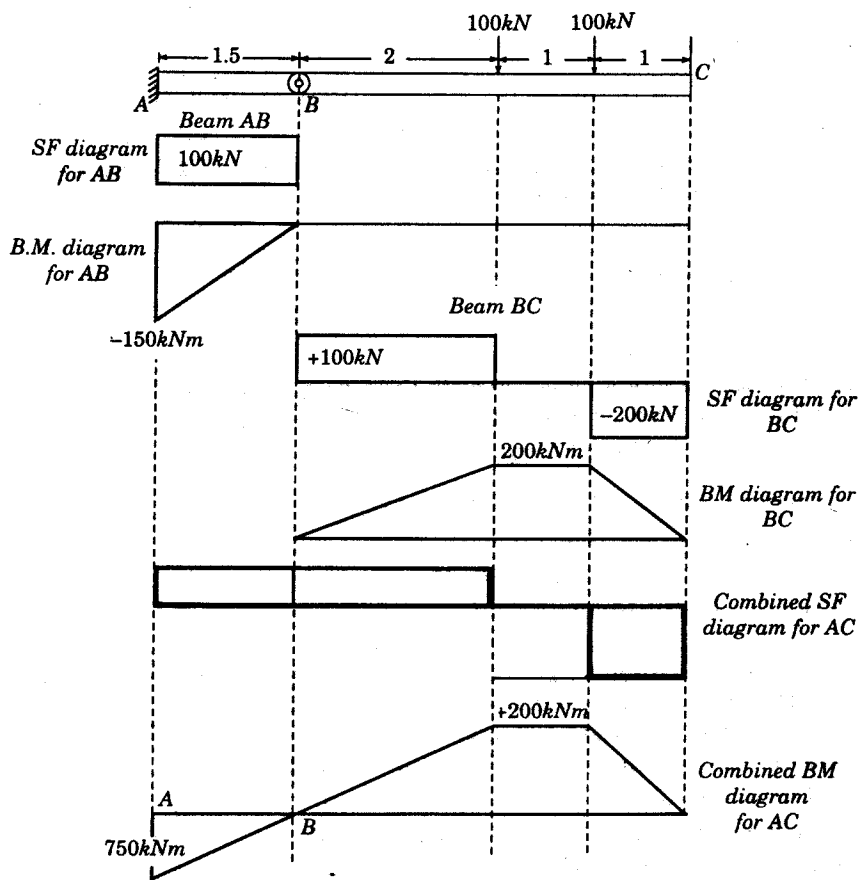


Fig. 16

Q. 1120. Fig. 17 shows theoretical compression and gas turbine process. Draw actual diagrams.

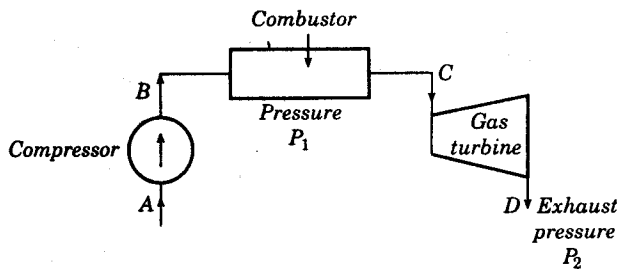


Fig. 17

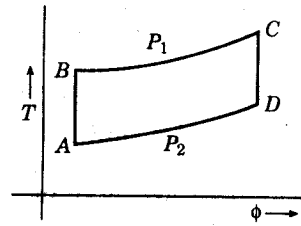


Fig. 18

Ans. Refer Fig. 18.

Q. 1121. In Fig. 19, block B whose centre is free to move along AC as well as constrained to move in vertical direction. Determine the velocity and acceleration of B.

Ans. Length $AB = \frac{l}{\cos \theta}$

Velocity of B \perp to AC = $\omega \times AB = \omega l / \cos \theta$

\therefore velocity of B in vertical direction = $l\omega / \cos^2 \theta$

Acceleration = $\frac{dV_B}{dt} = \frac{d}{dt} \left(\frac{l\omega}{\cos^2 \theta} \right) = l\omega \cdot \frac{-2}{\cos^3 \theta} (-\sin \theta) \frac{d\theta}{dt} = \frac{2l\omega^2 \sin \theta}{\cos^3 \theta}$

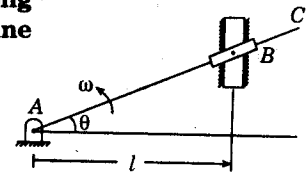


Fig. 19

Q. 1122. Determine the number of degrees of freedom of a 5-link plane mechanism with five revolute pairs shown in Fig. 20.

Ans. Degrees of freedom

$$= 3 (\text{number of links} - 1) - 2 \times \text{No. of single degree of freedom} - \text{number of 2 degree of freedom}$$

$$= 3 (5 - 1) - 2 \times 5 - 0 = 2.$$

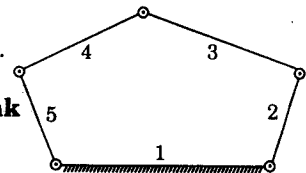


Fig. 20

Q. 1123. Fig. 21 shows a mass m attached to a cantilever beam of stiffness k_2 and is resting on a spring support of stiffness k_1 . Determine natural frequency of system.

Ans. Here supports k_1 and k_2 act in parallel on mass m

\therefore Equivalent stiffness = $k_1 + k_2$

and Natural frequency = $\frac{1}{2\pi} \sqrt{\frac{k_1 + k_2}{m}}$

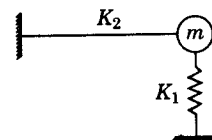


Fig. 21

Q. 1124. In a single stage single row impulse turbine, steam enters at velocity of 1000 m/s with nozzle angle of 20° and leaves the blade in axial direction. Ratio of blade velocity to tangential (whirl) velocity of steam is 0.6. How the velocity diagram will be drawn?

Ans. Draw horizontal line AC and draw AB = 1000 at 20° to AC. Take AD = 600. Join DB (V_{r1}).

Draw $AE \perp AC$ and take $DE = DB$. (Refer Fig. 22)

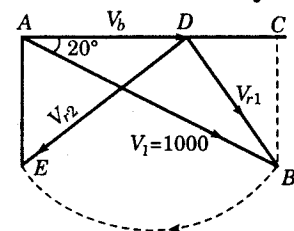


Fig. 22

Q. 1125. A circular link of length l is pinned at its ends and heated. Suggest a formula to raise temperature limit for the link to start buckling. (Refer Fig. 23)

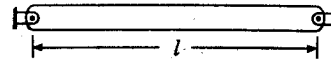


Fig. 23

Ans. $\delta l = l \alpha (\Delta T)$.

Also $\delta l = \frac{Pl}{AE}$ and $P = \frac{\delta l AE}{l}$

$P_{cr} = \frac{\pi^2 E I}{l^2}$, $\therefore \frac{\pi^2 E I}{l^2} = \frac{\delta l AE}{l}$ and $\Delta S = \frac{\pi^2 E I l}{l^2 \cdot AE}$

$\therefore \Delta T = \frac{\delta l}{l \alpha} = \frac{\pi^2 E I l}{l^2 AE \cdot l \alpha} = \frac{\pi^2 I}{l^2 A \alpha}$

Q. 1126. A rigid bar is hinged at A and supported in horizontal position by two vertical identical steel wires. A load F is applied as shown in Fig. 24. The tensions T_1 and T_2 in wires will be _____ ?

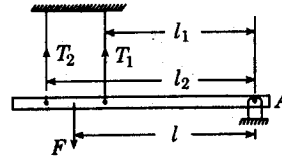


Fig. 24

Ans. $T_2 l_2 + T_1 l_1 = Fl$

Deflection in wires $\propto T$, Also $\frac{\delta_2}{l_2} = \frac{\delta_1}{l_1}$ or $\frac{T_2}{l_2} = \frac{T_1}{l_1}$

Multiplying first equation by l_2 ,

$T_2 l_2^2 + T_1 l_1 l_2 = Fl l_2$

and

$T_1 l_1 l_2 - T_2 l_1^2 = 0$, $\therefore T_2 = \frac{Fl_2 l}{l_1^2 + l_2^2}$

and

$T_1 = \frac{Fl_1 l}{l_1^2 + l_2^2}$

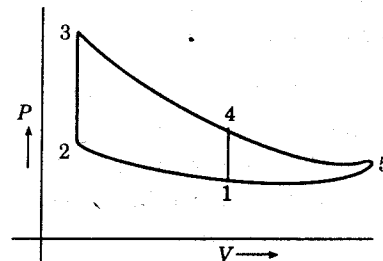


Fig. 25

Q. 1127. Name the cycle shown in Fig. 25.

Ans. Atkinson cycle.

Q. 1128. What is the discharge velocity at the pipe exit in Fig. 26 ?

Ans. $\sqrt{2gh}$.

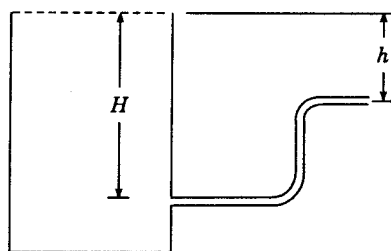


Fig. 26

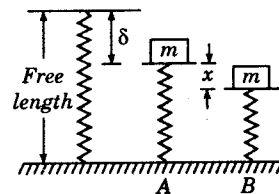


Fig. 27

Q. 1129. A spring of stiffness k has free length l . A mass m is placed on it and it deflects by δ . When vibrating, it is in position x below δ . Change in potential energy in this position is = _____ ? (Refer Fig. 27)

Ans. P.E. in position A = $mg(l - \delta)$

P.E. in position B = $mg[l - (\delta + x)] + \frac{1}{2} kx^2$

Change in energy = $\frac{1}{2} kx^2 - mgx$.

Q. 1130. Fig. 28 shows the temperature variation under steady heat conduction across a composite slab of two materials of thermal conductivities k_1 and k_2 . What is the relationship between k_1 and k_2 ?

Ans. $k_1 < k_2$

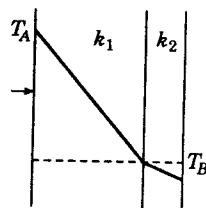


Fig. 28

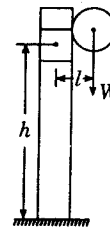


Fig. 29

Q. 1131. Fig. 29 shows a pole on which a signboard weight W kg at distance l is mounted at height h . What is the deflection of cantilever at end ?

Ans. Pole is subjected to load and bending moment at end

$$\therefore \text{deflection} = \frac{Wh^3}{3EI} + \frac{Wl \cdot h^2}{2EI}$$

Q. 1132. 1 mm diameter wire is proposed to be coated with enamel paint so as to increase heat transfer with air. What is the optimum thickness of paint ?

Ans. Critical radius of insulation $= k/h = \frac{0.1}{100} = 0.001 \text{ m} = 1 \text{ mm}$

Radius of wire = 0.5 mm

\therefore Thickness of coating = $1 - 0.5 = 0.5 \text{ mm}$.

Q. 1133. Determine pressure p at inlet to small pipe in Fig. 31 ?

Ans. $A_1V_1 = A_2V_2, \therefore V_2 = 8 \text{ m/s}$

$$\frac{p_1}{w} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{w} + \frac{V_2^2}{2g} + z_2$$

or $\frac{200 \times 1000}{9810} + \frac{2^2}{2 \times 9.81} + 0 = \frac{p_2}{w} + \frac{8^2}{2 \times 9.81} + 2$

or $p_2 = 150 \text{ kN/m}^2$.

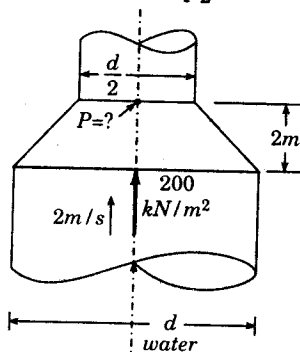


Fig. 31

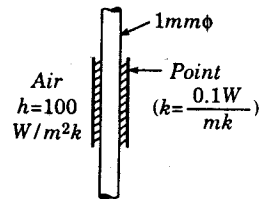


Fig. 30

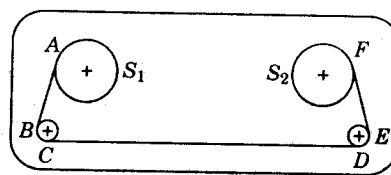


Fig. 32

Q. 1134. Fig. 32 shows an audio cassette mechanism. Where will be the instantaneous centre of rotation of the two spools S_1 and S_2 ?

Ans. It lies at the intersection of the line joining B and A , and the line joining E and F .

Q. 1135. Fig. 33 shows the stress-strain curve of a material under repeated loading. The material damping will be better as shaded area is ____ ?

Ans. smaller.

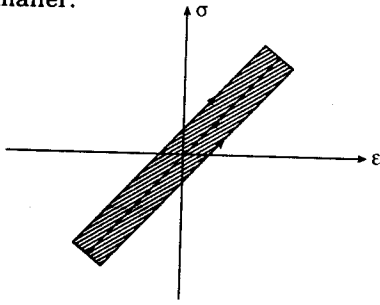


Fig. 33

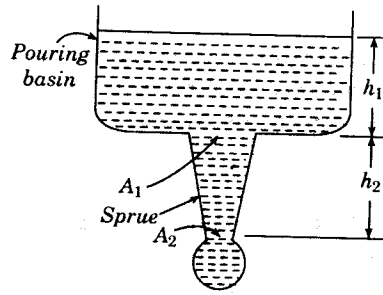


Fig. 34

Q. 1136. Fig. 34 shows a pouring basin and sprue for pouring molten metal in a mould. What is necessary condition for avoiding aspiration effect ?

Ans. To avoid aspiration effect, ratio of areas of sprue should be $\frac{A_2}{A_1} = \sqrt{\frac{h_1}{h_1 + h_2}}$.

Q. 1137. Fig. 35 shows a bulb A under a vacuum of 50 cm of mercury. The height h in pipe will be ____ ?

Ans. $h = 76 - 50 = 26$ cm.

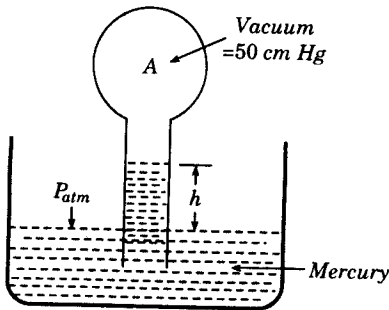


Fig. 35

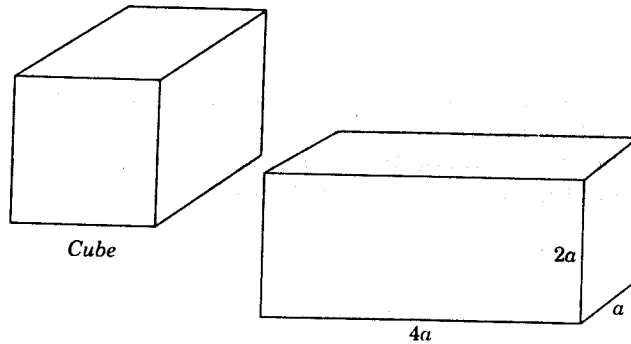


Fig. 36

Q. 1138. Fig. 36 shows a cube and slab of same volume. Determine the ratio of their solidification times.

Ans. Solidification time $\propto (V/A)^2$

Volume of slab = $4a \times 2a \times a = 8a^3$

\therefore Side of cube = $\sqrt[3]{8a^3} = 2a$

$A_{\text{cube}} = 6a^2, A_{\text{slab}} = 2(a + 2a + 2a \times 4a + a \times 4a) = 28a^2$

$\therefore \frac{t_{\text{cube}}}{t_{\text{slab}}} = \frac{A_{\text{slab}}}{A_{\text{cube}}} = \frac{28a^2}{6a^2} = 14:3$

Q. 1139. Fig. 37 shows the stress-strain behaviour of a material. Its resilience and toughness are ____ ?

Ans. Resilience = $\frac{1}{2} (70 \times 0.004) \times 10^6 = 14 \times 10^4 \text{ Nm/m}^3$

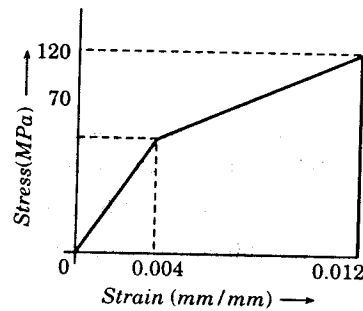


Fig. 37

$$\begin{aligned} \text{Toughness} &= \frac{1}{2} [70 \times 0.004 + (120 - 70) (0.012 - 0.004)] \times 10^6 \\ &= 90 \times 10^4 \text{ Nm/m}^3. \end{aligned}$$

Q. 1140. A simply supported beam carries a load 'P' through a bracket, as shown in Fig. 38. The maximum bending moment in the beam is _____ ?

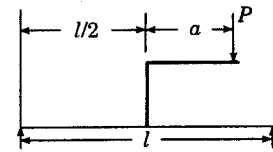


Fig. 38

Ans. $Pl/2 + aP$.

Q. 1141. An automobile of weight W is pulled by a pull P. What will be reaction on front wheels ?

Ans. Taking moments about A,

$$\begin{aligned} R_A \times 2a &= W \times a + P \times b \\ R_A &= \frac{Wa + Pb}{2a} = \frac{W}{2} + \frac{Pb}{2a}. \end{aligned}$$

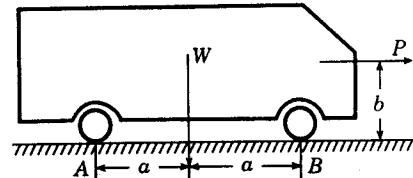


Fig. 39

Q. 1142. For the toggle device shown in Fig. 40, derive the relationship between force P and F.

Ans. If tension in arms be T, then $2T \sin \theta = P$

Also $F = T \cos \theta$

$\therefore P = 2F \tan \theta$.

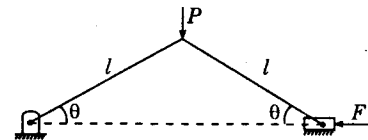


Fig. 40

Q. 1143. Fig. 41 shows a single block brake with a brake drum of radius r. It is to absorb torque T and coefficient of friction between drum and lining is μ . Calculate force P.

Ans. $\mu R = \frac{T}{r}, R = \frac{T}{\mu r}$

Taking moments about hinge,

$$P(l_1 + l_2) + \mu R \cdot l_3 = R \times l_1$$

or
$$P = \frac{Rl_1 - \mu Rl_3}{l_1 + l_2} = \frac{\mu T(l_1 - \mu l_3)}{r(l_1 + l_2)}$$

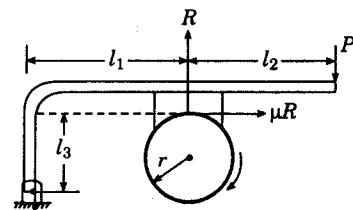


Fig. 41

Q. 1144. Sun gear in Fig. 42 rotates clockwise at 100 rpm. Determine the rotation of arm when ring gear is held stationary.

Ans.

	Arm	Sun	Planet	Ring
	+1	+1	+1	+1
	0	$\frac{80}{30} \times \frac{30}{20}$	$-\frac{80}{30}$	-1
	1	5	$-\frac{5}{3}$	0

If we lock arm and rotate ring by 1 rpm anticlockwise

\therefore If sun rotates at 5, arm will rotate at 1

\therefore for 100 rpm of sun, arm will rotate at 20 rpm.

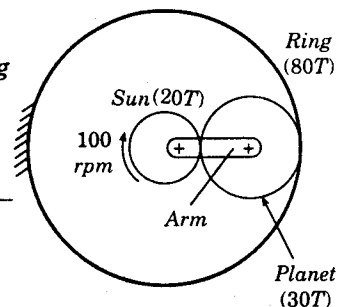


Fig. 42

Q. 1145. The assembly shown in Fig. 43 is composed of two massless rods of length l with two balls of mass 'm' each. What will be natural frequency of this assembly for small oscillations ?

Ans. When assembly is displaced by small angle $\delta\alpha$, then net restoring torque

$$= mg \cos(\alpha - \delta\alpha) l - mg(\alpha + \delta\alpha) l$$

$$= 2mg l \cos \alpha \sin \delta\alpha$$

For very small value of $\delta\alpha$, $\sin \delta\alpha = \delta\alpha$

$$\therefore \text{restoring torque} = 2mg l \cos \alpha \cdot \delta\alpha$$

$$I \frac{d^2\theta}{dt^2} + 2mg l \cos \alpha \cdot \delta\alpha = 0$$

since $I = 2ml^2$, $\therefore 2ml^2 \frac{d^2\theta}{dt^2} + 2mg l \cos \alpha \delta\alpha = 0$

or $\frac{d^2\theta}{dt^2} + \frac{g \cos \alpha}{l} \delta\alpha = 0$, $\therefore \omega_n = \sqrt{\frac{g \cos \alpha}{l}}$.

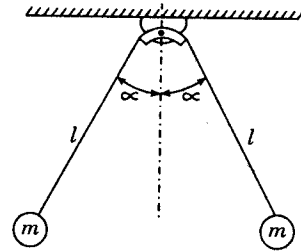


Fig. 43

Q. 1146. A spring-mass-dashpot system is shown in Fig. 44. Write the equation of motion to determine x .

Ans. Equating forces on the mass m ,

$$m \frac{d^2x}{dt^2} = F_0 \cos \omega t - C \frac{dx}{dt} - kx$$

or $m \frac{d^2x}{dt^2} + C \frac{dx}{dt} + kx = F_0 \cos \omega t$.

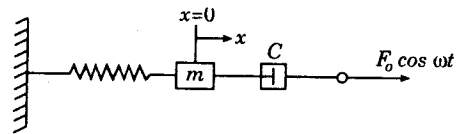


Fig. 44

Q. 1147. Fig. 45 shows a sphere and cylinder having same volume. If both are to be cast, which will solidify faster ?

Ans. $V_s = \frac{4}{3} \pi R^3$, $A_s = 4 \pi R^2$

$$V_c = \frac{\pi}{4} D^2 h = \frac{\pi}{4} D^3, \quad A_c = \pi D h + \frac{\pi}{4} \times D^2 \times 2 = \frac{3\pi}{2} D^2$$

Solidification time $\propto \frac{V}{S}$

$$\frac{V_s}{A_s} = \frac{\frac{4}{3} \pi R^3}{4 \pi R^2} = \frac{R}{3} = 0.333 R$$

$$\frac{V_c}{A_c} = \frac{\frac{\pi}{4} D^3}{\frac{3\pi}{2} D^2} = \frac{D}{6}$$

Since $V_s = V_c$

$$\therefore \frac{4}{3} \pi R^3 = \frac{\pi}{4} D^3 \quad \text{and} \quad D = \left(\frac{16}{3}\right)^{1/3} \frac{R}{6}$$

$$\therefore \frac{V_c}{A_c} = \left(\frac{16}{3}\right)^{1/3} \frac{R}{6} = 0.2962 R$$

\therefore Cylinder will solidify faster.

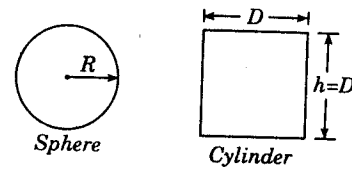


Fig. 45

Q. 1148. For the steam turbine and conditions of steam in inlet and outlet, determine the output of turbine. (Fig. 46)

Ans. Output = $m (h_1 - h_2) - \text{losses} = 0.25 (3486 - 3175.80) - 5 = 72.5 \text{ kW}$.

$P = 300 \text{ kPa}$
 $t = 500^\circ\text{C}$
 $h = 3486 \text{ kJ/kg}$
 $m = 0.25 \text{ kg/s}$

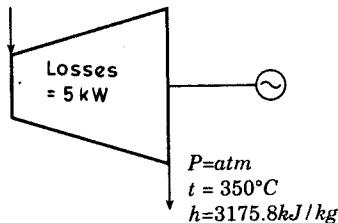


Fig. 46

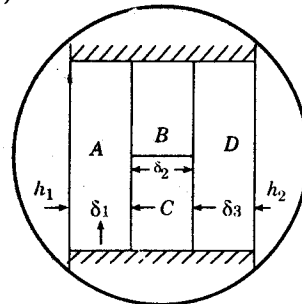


Fig. 47

Q. 1149. Fig. 47 shows a composite wall made of four different materials A, B, C and D. It is insulated at top and bottom. Sketch the thermal circuit of the system assuming one dimensional conduction.

Ans. Refer Fig. 48

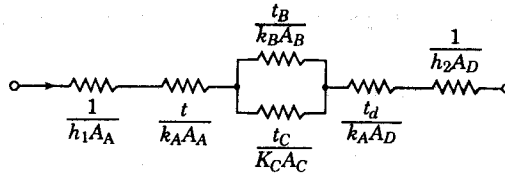


Fig. 48

Q. 1150. In a belt drive angle of wrap is increased from 160° to 200° by adding an idler as shown in Fig. 49. If slack side tension remains same, by what %age the torque capacity of belt is increased? Take $\mu = 0.3$

Ans. $\frac{T_1}{T_2} = e^{\mu\theta} = e^{0.3 \times 160 \times \frac{\pi}{180}} = e^{0.3 \times 2.79} = 2.309$

$\frac{T_1^1}{T_2} = e^{0.3 \times 200 \times \frac{\pi}{180}} = e^{0.3 \times 3.49} = 2.849$

Now $\frac{T_1 - T_2}{T_2} = 1.309$ and $\frac{T_1^1 - T_2}{T_2} = 1.849$

\therefore increase in capacity = $\frac{1.849 - 1.309}{1.309} = 41.25\%$.

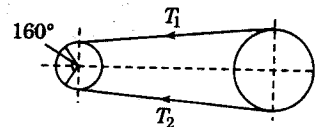


Fig. 49

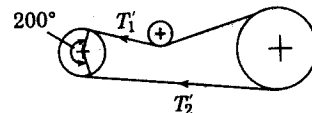


Fig. 50

Q. 1151. The 2 kg mass C moving horizontally to right, with a velocity of 5m/s, strikes the 8 kg mass B at the lower end of the rigid massless rod AB, 1.6 m long, suspended from a frictionless hinge at A. If coeff. of restitution between mass C and mass B is one, determine the angular velocity of rod immediately after the impact.

Ans. Relative velocity of approach = relative velocity of separation, or $5 = V_B' - V_C'$,

where V_B' and V_C' are velocity of B and C after impact.

As per conservation of linear momentum

$m_c V_c = m_B V_B' + m_c V_c'$

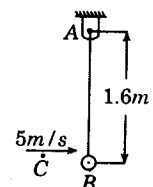


Fig. 51

$$2 \times 5 = 8 V_B' + 2V_C' = 8 V_B' + 2(V_B' - 5)$$

$$10 = 8 V_B' + 2V_B' - 10$$

or $10 V_B' = 20$ and $V_B' = 2 \text{ m/s}$

$$\therefore \omega = 2/1.6 = 1.25 \text{ rad/s.}$$

Q. 1152. Match the following in regard to units of pressure

- | | | | |
|---|--|-----|--------------------|
| 1 | 1 mm Hg | (a) | 1 ata |
| 2 | 1 kgf/cm ² | (b) | 1 atm |
| 3 | 10 ⁵ N/m ² | (c) | 1 torr |
| 4 | Standard atmospheric pressure of 760 mm Hg | (d) | 1 bar |
| 5 | 10 dyne/cm ² | (e) | 1 N/m ² |
| 6 | 1 pascal | (f) | 1 pascal |

Ans. 1—c, 2—a, 3—d, 4—b, 5—f, 6—e.

Q. 1153. Match the terms used in connection with heat treatment of steel with the micro-structural/physical characteristics.

- | <i>Term</i> | <i>Characteristic</i> |
|--------------|---|
| 1 Pearlite | (a) cementite finely dispersed in ferrite |
| 2 Martensite | (b) can exist only above 723°C |
| 3 Austenite | (c) extremely hard and brittle phase |
| 4 Eutectoid | (d) pertains to state of equilibrium between three solid phases |
| | (e) alternate layers of cementite and ferrite |

Ans. 1—e, 2—c, 3—b, 4—d.

Q. 1154. Match the following moulding/casting process with the product

- | <i>Moulding/casting process</i> | <i>Product</i> |
|---------------------------------|----------------------|
| 1 Shell moulding | (a) rain water pipe |
| 2 Slush moulding | (b) machine tool bed |
| 3 Centrifugal casting | (c) cylinder block |
| 4 Dry sand moulding | (d) turbine blade |
| | (e) hollow castings |

Ans. 1—(d), 2—(e), 3—(a), 4—(c).

Q. 1155. Match the instruments with the physical quantities they measure

- | <i>Instrument</i> | <i>Physical quantity</i> |
|-------------------|--------------------------|
| 1 Mcleod gange | (a) area |
| 2 Planimeter | (b) surface finsh |
| 3 Profilometer | (c) flow velocity |
| 4 Stroboscope | (d) vacuum |
| | (e) rpm of shaft |

Ans. 1—(d), 2—(a), 3—(b), 4—(e).

Q. 1156. Match the following quality control objective functions with appropriate statistical tools

<i>Objective Function</i>	<i>Statistical tool</i>
1. A casting process to be controlled with respect to hot tearing tendency	(a) \bar{x} -chart
2. A casting process to be controlled with respect to no. of blow holes/unit casting	(b) \bar{x} -chart
3. A machining process to be controlled with respect to diameter of shaft machined	(c) C-chart
4. Process variability in a milling operation to be controlled with respect to surface finish of components	(d) U-chart (e) p-chart

Ans. 1—(e), 2—(c), 3—(a), 4—(b).

Q. 1157. Match the following components with the appropriate machining process

<i>Component</i>	<i>Process</i>
1. Square hole in a high strength alloy	(a) ECM
2. Square hole in a ceramic component	(b) EDM
3. Blind holes in a die	(c) USM
4. Turbine blade profile on high strength alloy	(d) USM (e) jig boring

Ans. 1—(b), 2—(d), 3—(e), 4—(a).

Q. 1158. Match 4 correct pairs between list I and List II

<i>List I</i>	<i>List II</i>
(a) Hooke's law	1. Planetary motion
(b) St. Venant's law	2. Conservation of Energy
(c) Kepler's laws	3. Elasticity
(d) Tresca's criterion	4. Plasticity
(e) Coulomb's laws	5. Fracture
(f) Griffith's law	6. Inertia

Ans. (a)—3, (c)—1, (d)—5, (e)—2.

Q. 1159. List I gives a number of processes and List II gives a number of products. Match 4 correct pairs.

<i>List I</i>	<i>List II</i>
(a) Investment casting	1. Turbine rotor
(b) Die casting	2. Turbine blades
(c) Centrifugal casting	3. Connecting rods
(d) Drop forging	4. G.I. pipes
(e) Extrusion	5. Cast iron pipes
(f) Shell moulding	6. Carburettor body

Ans. (a)—2, (b)—6, (c)—5, (d)—3.

Q. 1160. For a perfect gas, match four correct pairs

<i>List I</i>	<i>List II</i>
(a) Isobaric thermal expansion coefficient	1. 0
(b) Isothermal compressibility	2. ∞
(c) Isentropic compressibility	3. $1/v$
(d) Joule - Thomson coefficient	4. $1/T$
	5. $1/p$
	6. $1/\gamma p$

Ans. (a)—4, (b)—5, (c)—6, (d)—1.

Q. 1161. Match 4 correct pairs in Lists I and II

<i>List I</i>	<i>List II</i>
(a) Collision of bodies	1. Kinetics
(b) Minimum potential energy	2. Reciprocating unbalance
(c) Degrees of freedom	3. Dynamics
(d) Prony brake	4. Coefficient of restitution
(e) Hammer blow	5. Stability
(f) Ellipse trammels	6. Gravity idler

Ans. (a)—4, (b)—5, (e)—2, (f)—3.

Q. 1162. Match four correct pairs from Lists I and II

<i>List I</i>	<i>List II</i>
(a) Strain rosette	1. Critical speed
(b) beams	2. Mohr's circle
(c) Section modulus	3. Coil springs
(d) Wahl's stress factor	4. Flexural rigidity
(e) Somerfield number	5. Endurance limit
	6. Core sector

Ans. (a)—2, (c)—4, (d)—3, (e)—5.

Q. 1163. Match 4 correct pairs between List I and List II.

<i>List I (Problem areas)</i>	<i>List II (Techniques)</i>
(a) JIT	1. CRAFT
(b) Computer assisted layout	2. PERT
(c) Scheduling	3. Johnson's rule
(d) Simulation	4. Kanbans
	5. EQQ rule
	6. Monte Carlo

Ans. (a)—4, (b)—1, (c)—3, (d)—6.

Q. 1164. Match List I and List II*List I (Manufacturing Processes)*

- (a) Finish turning
- (b) Forming
- (c) Thread cutting
- (d) Down milling

List II (Conditions)

- 1. Backlash eliminator
- 2. Zero rake
- 3. Nose radiusing
- 4. Low speed

Ans. (a)—3, (b)—2, (c)—4, (d)—1.

Q. 1165. Match List I and List II*List I (Measuring instruments)*

- (a) Talysurf
- (b) Telescopic gauge
- (c) Transfer callipers
- (d) Autocollimator

List II (Applications)

- 1. T-slots
- 2. Flatness
- 3. Internal diameter
- 4. Roughness

Ans. (a)—4, (b)—3, (c)—1, (d)—2.

Q. 1166. Match four pairs from list I and II*List I (Heat Engines)*

- (a) Gas Turbine
- (b) Petrol Engine
- (c) Stirling Engine
- (d) Diesel Engine

List II (Cycles)

- 1. Constant volume heat addition and constant volume heat rejection
- 2. Constant pressure heat addition and constant volume heat rejection
- 3. Constant pressure heat addition and constant pressure heat rejection
- 4. Heat addition at constant volume followed by heat addition at constant temperature
- 5. Heat rejection at constant volume followed by heat rejection at constant temperature

Ans. (a)—3, (b)—1, (c)—4, (d)—2.

Q. 1167. Match List I and List II*List I (Gear types)*

- (a) Worm gears
- (b) Cross helical gears
- (c) Bevel gears
- (d) Spur gears

List II (Applications)

- 1. Parallel shafts
- 2. Non-parallel, intersecting shafts
- 3. Non-parallel, non-intersecting shafts
- 4. Large speed ratios

Ans. (a)—4, (b)—3, (c)—2, (d)—1.

Q. 1168. Match 4 correct pairs between List I and List II*List I*

- (a) Collision of particles
- (b) Stability
- (c) Satellite motion
- (d) Spinning top

List II

- 1. Euler's equation of motion
- 2. Minimum kinetic energy
- 3. Minimum potential energy
- 4. Impulse-momentum principle
- 5. Conservation of moment of momentum

Ans. (a)—4, (b)—3, (c)—2, (d)—1.

Q. 1169. Match 4 pairs in Lists I and II*List I*

- (a) Fourier number
- (b) Weber number
- (c) Grashoff number
- (d) Schmidt number

List II

- 1. Surface tension
- 2. Forced convection
- 3. Natural convection
- 4. Radiation
- 5. Transient heat conduction
- 6. Mass diffusion

Ans. (a)—5, (b)—1, (c)—3, (d)—6.

Q. 1170. Match 4 pairs in Lists I and II.*List I*

- (a) Cetane number
- (b) Approach and range
- (c) $\left(\frac{\delta T}{\delta p}\right)_h \neq 0$
- (d) $dh = C_p dT$, even when pressure varies

List II

- 1. Ideal gas
- 2. Vander Waals gas
- 3. S.I. engine
- 4. C.I. engine
- 5. Cooling towers
- 6. Heat exchangers

Ans. (a)—4, (b)—5, (c)—2, (d)—1.

Q. 1171. Match 4 correct pairs between lists I and II.*List I*

- (a) Rivets for aircraft body
- (b) Carburettor body
- (c) Crankshafts
- (d) Nails

List II

- 1. Forging
- 2. Cold heading
- 3. Aluminium-based alloy
- 4. Pressure die casting
- 5. Investment casting

Ans. (a)—3, (b)—5, (c)—4, (d)—2.

Q. 1172. Match 4 correct pairs between lists I and II.*List I*

- (a) Welding of aluminium alloy
- (b) Ship building
- (c) Joining of HSS drill bit to carbon steel shank
- (d) Deep penetration precision welds

List II

- 1. Submerged arc welding
- 2. Electron beam welding
- 3. TIG welding
- 4. Gas welding

Ans. (a)—5, (b)—1, (c)—3, (d)—2.

Q. 1173. Match 4 correct pairs between List I and List II.*List I*

- (a) Steam nozzle
- (b) Compressible flow
- (c) Surface tension
- (d) Heat conduction

List II

- 1. Mach Number
- 2. Reaction Turbine
- 3. Biot Number
- 4. Nusselt Number
- 5. Supersaturation
- 6. Weber Number

Ans. (a)—5, (b)—1, (c)—6, (d)—3.

Q. 1174. Match 4 correct pairs between list I and II.

List I

- (a) Liquid to suction heat exchanger
- (b) Constant volume heat addition
- (c) Normal shock
- (d) Ammonia water

List II

- 1. Vapour absorption refrigeration
- 2. Vapour compression refrigeration
- 3. Diesel cycle
- 4. Otto cycle
- 5. Converging nozzle
- 6. Converging-diverging nozzle.

Ans. (a)—2, (b)—4, (c)—6, (d)—1.

Q. 1175. Match 4 correct pairs between lists I and II.

List I

- (a) Surface profilometer
- (b) Light Section Microscope
- (c) Microkater
- (d) Interferometer

List II

- 1. Calibration
- 2. Form tester
- 3. Film thickness measurement
- 4. Centre line average
- 5. Comparator
- 6. Surface lay measurement.

Ans. (a)—4, (b)—3, (c)—5, (d)—1.

Q. 1176. Match 4 correct pairs between lists I and II.

List I

- (a) Grinding
- (b) Honing
- (c) Superfinishing
- (d) Burnishing

List II

- 1. Surface for oil retention
- 2. Surface for max. load capacity
- 3. Surface of limiting friction
- 4. Surface of matte finish
- 5. Surface for pressure sealing
- 6. Surface for interference fit.

Ans. (a)—3, (b)—1, (c)—2, (d)—5.

Q. 1177. Match 4 correct pairs between lists I and II.

List I

- (a) Automobile wheel mounting on axle
- (b) High speed grinding spindle
- (c) I.C. Engine connecting rod
- (d) Leaf spring eye mounting

List II

- 1. Magneto bearing
- 2. Angular contact bearing
- 3. Taper roller bearing
- 4. Hydrodynamic journal bearing
- 5. Sintered metal bearing
- 6. Teflon/Nylon bush.

Ans. (a)—3, (b)—1, (c)—4, (d)—6.

Q. 1178. Match 4 correct pairs between List I and II.

List I

- (a) Heat to work
- (b) Heat to lift weight
- (c) Heat to strain energy
- (d) Heat to electromagnetic energy

List II

- 1. Nozzle
- 2. Endothermic chemical reaction
- 3. Heat engine
- 4. Hot air balloon/evaporation
- 5. Thermal radiation
- 6. Bimetallic strips

Ans. (a)—3, (b)—4, (c)—6, (d)—5.

Q. 1179. Match 4 correct pairs between lists I and II.

- | <i>List I</i> | <i>List II</i> |
|---------------------------|--|
| (a) Sand casting | 1. Symmetrical and circular shapes only |
| (b) Plaster mould casting | 2. Parts have hardened skins and soft interior |
| (c) Shell mould casting | 3. Minimum post-casting processing |
| (d) Investment casting | 4. Parts have a tendency to warp |
| | 5. Parts have soft skin and hard interior |
| | 6. Suitable only for non-ferrous metals |

Ans. (a)—4, (b)—6, (c)—5, (d)—3.

Q. 1180. Match 4 correct pairs between lists I and II.

- | <i>List I</i> | <i>List II</i> |
|------------------------------|---------------------|
| (a) High head, low flow rate | 1. Streamlined body |
| (b) Low head, high flow rate | 2. Boundary layer |
| (c) Heat transfer | 3. Orifice meter |
| (d) Low drag | 4. Centrifugal pump |
| | 5. Axial flow pump |
| | 6. Nusselt number |

Ans. (a)—4, (b)—5, (c)—6, (d)—1.

Q. 1181. Match 4 pairs from List I and List II.

- | <i>List I</i> | <i>List II</i> |
|--------------------------------|------------------------|
| (a) Aluminium brake shoe | 1. Deep drawing |
| (b) Plastic water bottle | 2. Blow moulding |
| (c) Stainless steel cups | 3. Sand casting |
| (d) Soft drink can (aluminium) | 4. Centrifugal casting |
| | 5. Impact extrusion |
| | 6. Upset forging |

Ans. (a)—3, (b)—2, (c)—5, (d)—1.

Q. 1182. Match 4 pairs from Lists I and II

- | <i>List I</i> | <i>List II</i> |
|---------------|---------------------------------------|
| (a) ECM | 1. Plastic shear |
| (b) EDM | 2. Erosion/Brittle fracture |
| (c) USM | 3. Corrosive reaction |
| (d) LBM | 4. Melting and vapourization |
| | 5. Ion displacement |
| | 6. Plastic shear and ion displacement |

Ans. (a)—3, (b)—6, (c)—2, (d)—4.

Q. 1183. Which can has constant acceleration ?

Ans. From Fig. 46, it will be seen that parabolic motion can has constant acceleration.

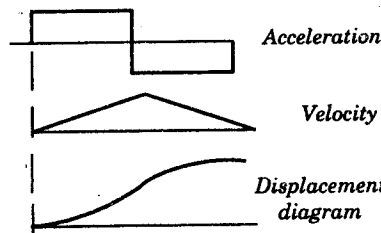


Fig. 52

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