OBJECTIVE PAPER-II

1. Consider the following motions:
1. Piston reciprocating inside an engine cylinder
2. Motion of a shaft between foot-step bearings

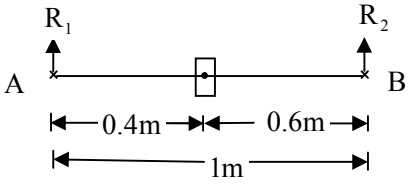
Which of the above can rightly be considered as successfully constrained motion?
(A) 1 only (B) 2 only
(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (C)

2. A rotor weighing 2 kN is supported on bearings A and B which are 1 m apart. The centre of mass of the rotor is at a distance 0.4 m from bearing A. It is observed that there is an unbalanced couple of magnitude 300 N-m which leaves the shaft balanced statically. The dynamic reactions at the supports will be
(A) 800 N and 800 N
(B) 300 N and 800 N
(C) 800 N and – 300 N
(D) 300 N and – 300 N

Key: (D)

Sol:



$R_1 + R_2 = 0$ Static balance

$R_1 = 300N$

$R_2 = -300N$

and Couple $= 300 \times 1 = 300\ N-m$

3. A cam is a mechanical member used to impart a desired motion to a follower by direct contact. Which one of the under-listed follower motion types will produce the least jerk to the system?
(A) Simple harmonic
(B) Constant acceleration and deceleration
(C) Constant velocity
(D) Cycloidal

Key: (D)

4. In a circular arc cam with a roller follower, acceleration of the follower depends on
1. cam speed and location of centre of circular arc
2. roller diameter and radius of circular arc

Which of the above is /are correct?
(A) 1 only (B) 2 only
(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (C)

5. A manufacturing company is selling a product for 15 per unit with variable cost of 10 per unit. The fixed cost of the asset is 50,000. How many units should be produced to breakeven?
(A) 2000 (B) 5000
(C) 8000 (D) 10000

Key: (D)

Sol: $Q = \dfrac{F}{S - V} = \dfrac{50000}{15 - 10} = 10000$

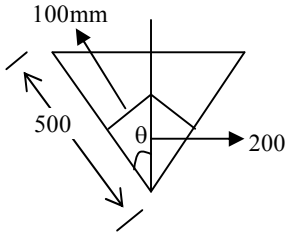
6. In a crank and slotted lever quick return motion mechanism, the distance between the fixed centre's is 200 mm. The lengths of the driving crank and the slotted bar are 100 mm and 500 mm, respectively. The length of the cutting stroke is
(A) 100 mm (B) 300 mm
(C) 500 mm (D) 700 mm

Key: (C)

Sol: Stroke

$$= \frac{2(\text{Length of slotted bar}) \times (\text{Length of Crank})}{(\text{Length CR})}$$

$$= \frac{2 \times 500 \times 100}{200} = 500mm$$



$\text{Sin}\,\theta = \dfrac{100}{200} \Rightarrow \theta = 30^\circ$

Stroke length = 2×500sin30° = 500mm.

7. A gear of 28 cm pitch circle diameter has 40 teeth. The circular pitch will nearly be
(A) 11 mm/tooth (B) 22 mm/tooth
(C) 33 mm/tooth (D) 44 mm/tooth

Key: (B)

Sol: $P_c = \frac{\pi D}{T} = \frac{\pi \times 280}{40}$
$= 7\pi = 21.99 \text{ mm/tooth}$
$= 22 \text{mm/tooth}$

8. Consider the following statements regarding gear tooth designing for gear drive:
1. Tooth profiles not designed as per 'law of gearing' will cause vibration and impact problems even at low speed.
2. As the gears go through their mesh, the pitch point must remain stationary on the line of centres.
3. In a correctly designed tooth profile, the line of action of successive instantaneous points of contact will pass through the stationary pitch point.
Which of the above statements are correct?
(A) 1, 2 and 3 (B) 1 and 2 only
(C) 1 and 3 only (D) 2 and 3 only

Key: (A)

9. The flywheel of a steam engine has a radius of gyration of 1 m and mass 2000 kg. The starting torque of the engine is 2000 N-m. The kinetic energy of the flywheel after 10 seconds from start is
(A) 75 kN-m (B) 100 kN-m
(C) 125 kN-m (D) 150 kN-m

Key: (B)

Sol: $I = mk^2 = 2000 \times (1)^2 = 2000$
$T = 2000 N - m$
$T = I\alpha$
$2000 = 2000 \times \alpha$
$\alpha = 1 \text{rad/s}^2$
After 10 sec,
$\omega = \omega_0 + \alpha t = 0t + 1 \times 10 = 10 \text{rad/s}$
$E = \frac{1}{2} I\omega^2 = \frac{1}{2} \times 2000 \times 10 \times 10$
$= 10^5 = 100 \text{kN} - \text{m}$

10. Consider two shafts connected with two gears as per the following options:
1. One on each shaft
2. Through an intermediate gear mounted on an intermediate shaft, and every shaft having one gear only
3. Through an intermediate gear mounted on an intermediate shaft, with the intermediate shaft having two gears, whereas the other shafts have one gear each
Which of the above represent(s) a simple gear train?
(A) 1 only (B) 1 and 2 only
(C) 2 and 3 only (D) 1, 2 and 3

Key: (B)

11. A riveting machine is driven by a constant-torque 3 kW motor. The moving parts including the flywheel are equivalent to 150 kg at 0.6 m radius. One riveting operation takes 1 second and absorbs 10000 N-m of energy. The speed of the flywheel is 300 r.p.m. before riveting. What is the speed (to nearest 10 r.p.m.) after riveting and what is the number of rivets that can be closed per minute?
(A) 260 r.p.m. and 18 (B) 290 r.p.m. and 15
(C) 360 r.p.m. and 18 (D) 390 r.p.m. and 15

Key: (A)

Sol: P = 3000 watt
m = 150 kg
R = 0.6 m
$I = mR^2 = 54 \text{ kg-m}^2$
Cycle Time = x sec.
Exact riveting time = 1 sec
$E_{\text{Rivet}} = (10000 \text{ N-m})$
$P = 3000 = 10000 \times \frac{1}{x}$
$x = \frac{10000}{3000} = 3.333 \text{sec}$

$1\,\text{Rivet}/3.333\,\text{sec}$

$$\text{No. of rivet}/\text{Min} = \frac{60}{3.333} = 18$$

$$10000 - (3000 \times 1) = I\omega^2.C_S = \frac{1}{2}I\omega^1_{max} - \frac{1}{2}I\omega^2_{min}$$

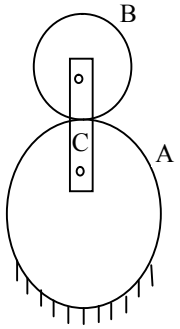
$$7000 = \frac{1}{2} \times 54\left(300^2 - N^2_{min}\right) \times \left(\frac{2\pi}{60}\right)^2$$

$$N^2_{min} = 300^2 - 23641$$

$$N_{min} = 257.601\,\text{rpm}$$

$$= 260\,\text{rpm}$$

12. With respect to the epicyclic gear train shown in the given figure, A has 75 teeth and B has 25 teeth; A is fixed and arm C makes 5 revolutions:
The number of revolutions made by B is



(A) 10 (B) 15 (C) 20 (D) 25

Key: (C)

Sol:

Arm C	A(75)	B(25)
0	+x	$-x \times \frac{75}{25}$
y	$(y+x)$	$(y-3x)$

$y + x = 0$
$y = 5$
$x = -5$
$N_B = y - 3x = 5 - 3(-5) = 5 + 15 = 20$

13. The equation of motion of a linear vibratory system with a single degree of freedom is

$$4\ddot{x} + 9\dot{x} + 16x = 0$$

The critical damping coefficient for the system is
(A) 32 (B) 16 (C) 8 (D) 4

Key: (B)

Sol: $4\ddot{x} + 9\dot{x} + 16x = 0$

$$2 \text{ and } \omega_n = \frac{C}{m} = \frac{9}{4}$$

If $\xi = 1$

$$\omega_n^2 = 4, \omega_n = 2, m = 4\text{kg}$$

$$\Rightarrow C = C_c \Rightarrow 2\omega_n = \frac{C_c}{m}$$

$$2 \times 2 = \frac{C_c}{4} \Rightarrow C_c = 16$$

14. Which one of the following statements is correct?
(A) The product of diametral pitch and circular pitch is equal to unity.
(B) The pressure angle for involute gears depends upon the size of teeth.
(C) In a gear having involute teeth, the normal to the involute is a tangent to the base circle.
(D) For commercially cut gears, the limiting pitch line velocity is 60 m/min.

Key: (C)

15. The thickness of the continuous weld used for connecting a horizontal square bar of 150 mm size and of cantilevered length 500 mm to a vertical plate, with the bar carrying a 25 kN vertical load at its outer tip, given that the permissible direct shear stress of the weld is 20 N/mm^2, is
(A) 3 mm (B) 4 mm
(C) 5 mm (D) 6 mm

Key: (A)

Sol: $P_{max} = 0.707\ t.\ell.\tau_{per}$

Where t=size(or) thickness of weld

$$25 \times 10^3 = 0.707 \times t \times 4 \times 150 \times 20$$

or $t = 2.94\,\text{mm} = 3\text{mm}$

16. A shaft of 50 mm diameter transmits a torque of 800 N-m. The width of the rectangular key used is 10 mm. The

allowable shear stress of the material of the key being 40 MPa, the required length of the key would be
(A) 60 mm (B) 70 mm
(C) 80 mm (D) 90 mm

Key: (C)

Sol: $\tau_{per} = \frac{2T}{b\ell D}$

$40\times10^{6} = \frac{2\times800}{0.01\times0.05\times d}$

$d = 0.08m = 80mm$

17. A governor is said to be hunting if the speed of the engine
(A) remains constant at the mean speed
(B) is above the mean speed
(C) is below the mean speed
(D) fluctuates continuously above and below the mean speed

Key: (D)

18. The diameter of the pin in a bushed pin type flexible coupling is to be increased for the purpose of
(A) higher stress due to shear
(B) keeping the magnitude of bending moment small by reducing the unsupported length of the pin
(C) fitting the pin in the bush
(D) reducing the thickness of the flange

Key: (C)

Sol: In design of flexible flange coupling, first the rubber bush dimensions are determined based on pressure acting on it and bearing pressure capacity of rubber bush. In order to fit into the rubber bush in the left flange the diameter of the pin will be increased even though its diameter is less according to bending stress and shear stress failure of pin. It also help in reducing bearing pressure acting on rubber bush. Hence statement C is correct.

19. The problem of interference involute profile gears can be overcome by which one of the following means?
(A) Decreasing the centre distance
(B) Using composite profile with cycloidal curve at the root of the tooth
(C) Using stub teeth of height more than the full depth teeth
(D) Proper lubrication

Key: (B)

20. The bearing modulus for a bearing is 1628. What is the bearing characteristic number considered for bearing design?
(A) 1628 (B) 3256 (C) 4884 (D) 6512

Key: (D)

Sol: To operate always journal bearings in stable region the bearing characteristic number should be greater than (or) equal to '3' times bearing modulus.

Means $\frac{Zn}{p} \geq 3\alpha$

where $\frac{Zn}{p}$ – Bearing characteristic number

α – Bearing modulus

$3\alpha = 3\times1628 = 4884$

To be on more safe side we can take more than that value i.e, $4\alpha = 6512$ also.

Hence bearing characteristic number considered for bearing design is 6512.

21. Two shafts of diameter 30 mm each are connected by a flange coupling. Six bolts, each of diameter 8 mm, are used on a pitch circle of diameter 90 mm. If the allowable shear stress of the bolt material is 80 MPa, what is the torque-transmitting capacity of the bolts to the nearest 10 units?
(A) 780 N-m (B) 950 N-m
(C) 1090 N-m (D) 1250 N-m

Key: (C)

22. While selecting the elements of power transmission with speed reduction, the order of preference based on a minimum cost is
(A) spur gear, belt pulley, worm and worm wheel
(B) belt pulley, spur gear, worm and worm wheel

(C) worm and worm wheel, spur gear, belt pulley
(D) worm and worm wheel, belt pulley, spur gear

Key: (B)

23. A solid shaft is designed to transmit 100 kW while rotating at N r.p.m. If the diameter of the shaft is doubled and is allowed to operate at 2 N r.p.m., the power that can be transmitted by the latter shaft is
(A) 200 kW (B) 400 kW
(C) 800 kW (D) 1600 kW

Key: (D)

Sol: $P_{max} = \frac{2\pi N}{60}\left[\frac{\pi d^3 \tau_{per}}{16}\right]$

24. What shall be the centre distance between the axes of pinion and gear when a 20° full-depth involute profile pinion with 20 teeth meshes with a gear that has 50 teeth for a module of 6 mm?
(A) 70 mm (B) 140 mm
(C) 210 mm (D) 280 mm

Key: (C)

Sol: Centre distance = R + S

$$= \frac{mT}{2} + \frac{mt}{2} = \frac{6\times 50}{7} + \frac{6\times 20}{2}$$

$$= 150 + 60 = 210\text{mm}$$

25. The diameter of a shaft to transmit 25 kW at 1500 r.p.m., given that the ultimate strength is 150 MPa and the factor of safety is 3, will nearly be
(A) 12 mm (B) 16 mm
(C) 20 mm (D) 26 mm

Key: (D)

26. A thick lubrication is
(A) a stable lubrication and there is no metal to metal contact
(B) a stable lubrication because there is some amount of metal to metal contact
(C) an unstable lubrication because there is some amount of metal to metal contact
(D) an unstable lubrication because there is no metal to metal contact

Key: (A)

27. A journal bearing sustains a radial load of 3672 N. The diameter of the bearing is 50 mm and the length is 0.1 m. The diametral clearance is 0.1 mm and the shaft rotates at 500 r.p.m. If the absolute viscosity of the oil is 0.06 kg/m-s, the value of Somerfeld number is
(A) 5.2×10^6 (B) 10.3×10^6
(C) 15.2×10^6 (D) 20.3×10^6

Key: (B)

Sol: P = 3672N, d = 50mm, l = 0.1m = 100mm, c_d = 0.1mm, N = 500rpm, Z = 0.06kg/m – sec, S = ?, $P = \frac{W}{\ell d}$

$$S = \left(\frac{Zn}{P}\right)\left(\frac{d}{c_d}\right)^2$$

$$= \left(\frac{0.06\times 500}{\left(\frac{3672}{100\times 50}\right)}\right)\left(\frac{50}{0.1}\right)^2$$

$$= 10.212\times 10^6 \cong 10.3\times 10^6$$

28. If the dynamic load capacity of a ball bearing is increased to 1.5 times its earlier value
without changing its equivalent load, the life of the bearing increases to
(A) 6.4 times its earlier life
(B) 5.2 times its earlier life
(C) 4.2 times its earlier life
(D) 3.4 times its earlier life

Key: (D)

Sol: Life of a ball bearing is given by

$$L = \left(\frac{C}{P}\right)^3$$

Where L =life of ball bearing

C = Dynamic load carrying capacity

P = Applied equivalent load

$$L_1 = \left(\frac{C}{P}\right)^3, L_2 = \left(\frac{1.5C}{P}\right)^3$$

$$\frac{L_2}{L_1} = (1.5)^3 = 3.375 \simeq 3.4$$

$$L_2 = 3.4L_1$$

29. The speed of the crankshaft is found to vary between 120 r.p.m. and 150 r.p.m. during one cycle of operation. What is the coefficient of fluctuation of speed?

(A) 0.40 (B) 0.31 (C) 0.22 (D) 0.13

Key: (C)

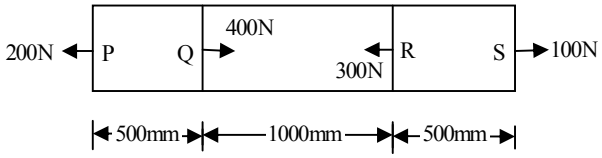
Sol: $N_{max} = 150\text{rpm}$

$N_{min} = 120\text{rpm}$

$$N = \frac{150+120}{2} = 135\text{rpm}$$

$$C_B = \frac{150-120}{135} = \frac{30}{135} = 0.222$$

30. A steel rod of cross-sectional area 10 mm^2 is subjected to loads at points P, Q, R and S as shown in the figure below:



If E_{steel} = 200 GPa, the total change in length of the rod due to loading is

(A) – 5 μm (B) – 10 μm

(C) -20 μm (D) - 25 μm

Key: (D)

Sol: $\Delta = \Delta_{PQ} + \Delta_{QR} + \Delta_{RS}$

$$= \frac{F_{PQ}L_{PQ}}{AE} + \frac{F_{QR}L_{QR}}{AE} + \frac{F_{RS}L_{RS}}{AE}$$

$$= \frac{1}{AE}\left[(200\times 0.5) + (-200\times 1) + (100\times 0.5)\right]$$

$$= \frac{100-200+50}{10\times 10^{-6}\times 200\times 10^{9}} = -25\times 10^{-6}\,\text{m}$$

$$= -25\mu\text{m}$$

31. The state of stress at a point when completely specified enables one to determine the

1. maximum shearing stress at the point

2. stress components on any arbitrary plane containing that point

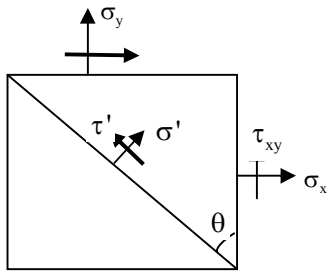
Which of the above is/are correct?

(A) 1 only (B) 2 only

(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (C)

Sol:



Max shear stress, $\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right) + \tau_{xy}^2}$

Normal stress on oblique plane

$$\sigma' = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\tau' = \left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta + \tau_{xy}\cos 2\theta$$

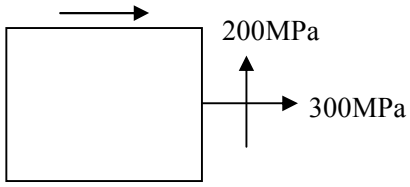
32. A body is subjected to a direct tensile stress of 300 MPa in one plane accompanied by a simple shear stress of 200 MPa. The maximum normal stress at that point will be

(A) 100 MPa (B) 200 MPa

(C) 300 MPa (D) 400 MPa

Key: (D)

Sol:



Max normal stress,

$$\sigma_1 = \frac{300}{2} + \sqrt{\left(\frac{300}{2}\right)^2 + 200^2}$$

$$= 150 + \sqrt{150^2 + 200^2} = 400\text{MPa}$$

33. A hub is press fitted on a shaft. An element in the hub is subjected to a radial compressive stress of 50 N/mm^2 and hoop stress of 75 N/mm^2. If the hub is made of 30C8 steel with yield strength, σ_y = 350 N/mm^2, what is the factor of safety using maximum shear stress theory?

(A) 2.8 (B) 3.6 (C) 4.2 (D) 5.6

Key: (A)

Sol: In hub, radial stress is comp

$$\sigma_r = -50\ N/mm^2$$

and hoop stress is tensile

$$\sigma_h = +75\ N/mm^2$$

$\therefore$ absolute max shear stress

$$\tau_{max} = \frac{\sigma_h - \sigma_r}{2} = \frac{125}{2} N/mm^2$$

According to maximum shear stress theory

$$\tau_{max\,abs} \le \frac{\sigma_y}{2FOS}$$

$$\frac{125}{2} = \frac{350}{2 \times FOS}$$

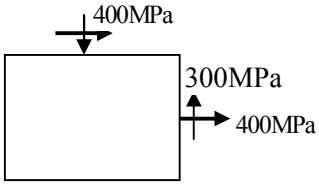
$$\therefore FOS = \frac{350}{125} = 2.8$$

34. The state of stress at a point in a loaded member is σ_x=400 MPa, σ_y = – 400 MPa and σ_{xy}= ± 300 MPa. The principal stresses σ_1 and σ_2 are

(A) 300 MPa and – 700 MPa
(B) 400 MPa and – 600 MPa
(C) 500 MPa and – 500 MPa
(D) 600 MPa and – 400 MPa

Key: (C)

Sol:



Principal stress,

$$\sigma_1, \sigma_2 = \frac{400 - 400}{2} \pm \sqrt{\left(\frac{400 + 400}{2}\right)^2 + 300^2}$$

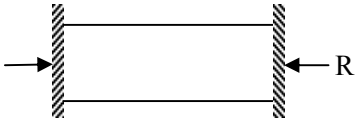
$$= \pm\sqrt{400^2 + 300^2} = \pm 500 MPa$$

35. A circular steel rod of 20 cm^2 cross-sectional area and 10 m length is heated through 50°C with ends clamped before heating. Given, E = 200 GPa and coefficient of thermal expansion, $\alpha = 10 \times 10^{-6}$/°C, the thrust thereby generated on the clamp is

(A) 100 kN (B) 150 kN
(C) 200 kN (D) 250 kN

Key: (C)

Sol:



$$\Delta_{act} = 0$$

Δ due to temp change

$= \Delta$ due to compressive reaction force.

$$L\alpha.\Delta T = \frac{RL}{AE}$$

$$\therefore R = \alpha.\Delta T.AE$$

$$= 10 \times 10^{-6} \times 50 \times 20 \times 10^{-4} \times 200 \times 10^9$$

$$= 200 \times 10^3 N = 200 kN$$

36. Two steel rods of identical length and material properties are subjected to equal axial loads. The first rod is solid with diameter d and the second is a hollow one with external diameter D and interned diameter 50% of D. If the two rods experience equal extensions, the ratio of $\frac{d}{D}$ is

(A) $\frac{3}{4}$ (B) $\frac{\sqrt{3}}{2}$ (C) $\frac{1}{2}$ (D) $\frac{1}{4}$

Key: (B)

Sol: $\Delta_s = \Delta h$

$$\frac{PL}{A_S.E} = \frac{PL}{A_H.E}$$

$$\therefore A_S = A_H$$

$$d^2 = D^2 - \left(\frac{D}{2}\right)^2$$

$$d^2 = \frac{3D^2}{4}$$

$$\frac{d}{D} = \frac{\sqrt{3}}{2}$$

37. A steel rod 10 m long is at a temperature of 20°C. The rod is heated to a temperature of 60°C. What is the stress induced in the rod if it is allowed to expand by 4 mm, when E = 200 GPa and $\alpha = 12 \times 10^{-6}$/°C?

(A) 64 MPa (B) 48 MPa
(C) 32 MPa (D) 16 MPa

Key: (D)

Sol: Free expansion = $L.\alpha.\Delta T = 10 \times 10^3 \times 12 \times 10^{-6} \times 40 = 4.8mm$

Actual expansion = 4 mm

$\therefore$ expansion resisted $= 0.8mm$

$$\therefore \text{strain resisted} = \frac{0.8}{10000}$$

$$\therefore \text{stress developed} = \frac{0.8}{10000} \times E$$

$$= \frac{0.8}{10000} \times 200 \times 10^3 = 16MPa$$

38. A metal piece under the stress state of three principal stresses 30, 10 and 5 kg/mm^2 is undergoing plastic deformation. The principal strain rates will be in the proportions of

(A) 15, – 5 and – 10 (B) – 15, 5 and – 10
(C) 15, 5 and 10 (D) – 15, – 5 and 10

Key: (A)

Sol: For plastic deformationμ=0.5

Principal strain

$$\in_1 = \frac{\sigma_1}{E} - \frac{\mu\sigma_1}{E} - \frac{\mu\sigma_3}{E}$$

$$= \frac{30 - (0.5 \times 10) - (0.5 \times 5)}{E} = \frac{22.5}{E}$$

$$\in_2 = \frac{\sigma_2}{E} - \frac{\mu\sigma_1}{E} - \frac{\mu\sigma_3}{E}$$

$$= \frac{10 - (0.5 \times 30) - (0.5 \times 5)}{E}$$

$$\in_2 = \frac{-7.5}{E} \text{ and } \in_3 = \frac{\sigma_3}{E} - \frac{\mu\sigma_1}{E} - \frac{\mu\sigma_2}{E}$$

$$= \frac{5 - (0.5 \times 30) - (0.5 \times 10)}{E} = \frac{-15}{E}$$

$$\therefore \in_1 : \in_2 : \in_3 = 22.5 : -7.5 : -15$$

$$= 15 : -5 : -10$$

39. An isotropic elastic material is characterized by

(A) two independent moduli of elasticity along two mutually perpendicular directions
(B) two independent moduli of elasticity along two mutually perpendicular directions and Poisson's ratio
(C) a modulus of elasticity, a modulus of rigidity and Poisson's ratio
(D) any two out of a modulus of elasticity, a modulus of rigidity and Poisson's ratio

Key: (D)

Sol: Isotropic material is characterized by two independent elastic constant.

40. The Miller indices of a material in a plane are proportional to

(A) the reciprocal of numerical parameters of the intercepts
(B) the square of unit cell dimensions
(C) the intercepts of the planes on the coordinate axes
(D) the interplanar spacing

Key: (A)

41. Endurance limit is of primary concern in the design of a/an

1. rotating shaft
2. industrial structure
3. column
4. machine base

Which of the above is/are correct?

(A) 1 only (B) 2 only
(C) 3 and 4 only (D) 1, 2, 3 and 4

Key: (A)

Sol: Endurance limit is the design criteria for cyclic loading.

42. A simply supported beam of rectangular cross-section is under transverse loading. Regarding the shear stress distribution across any section, the ratio of maximum shear stress to mean shear stress is

(A) 1.5 (B) 2.5 (C) 3.5 (D) 4.5

Key: (A)

Sol: For rectangular section under transverse shear loading, $\tau_{max} = \frac{Vh^2}{8I_X}$,

But for rectangular section, $I_X = \frac{bh^3}{12}$

Hence, $\tau_{max} = \frac{3}{2}\frac{V}{bh} = 1.5\tau_{mean}$

43. Two beams, one having a square cross-section and another a circular cross-section, are subjected to the same amount of bending moment. If the cross-sectional area as well as the material of both the beams are the same, then

1. both the beams will experience the same amount of deformation
2. the circular beam experiences more extreme flexural stress than the square one

Which of the above is/are correct?

(A) 1 only (B) 2 only
(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (B)

Sol: In case of bending square section is more stronger than the circular section since the section modulus (z) of square section is more as compared to circular section.

$$\therefore \sigma = \frac{M}{Z}$$

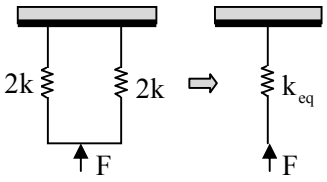
bending stress in circular section is more as compared to square section.

44. A coil-spring of stiffness k is cut exactly at the middle and the two springs thus made are arranged in parallel to take up together a compressive load. The equivalent stiffness of the two springs is

(A) 0.25 k (B) 0.5 k (C) 2 k (D) 4 k

Key: (D)

Sol: If the spring is cut in two equal half then stiffness of both the spring gets double.



$$k_{eq} = 2k + 2k = 4k$$

45. Two solid shafts A and B are made of the same material. Shaft A is of 50 mm diameter and shaft B is of 100 mm diameter. The strength of shaft B is

(A) 2 times as that of shaft A
(B) 4 times as that of shaft A
(C) 6 times as that of shaft A
(D) 8 times as that of shaft A

Key: (D)

Sol: For shaft in torsion, strength depends on polar section modulus,

$\because$ polar section modulus $Z_p \propto d^3$

$\therefore$ Shaft B is 8 times stronger than A.

46. A closely-coiled helical spring is made of 10 mm diameter steel wire, with the coil consisting of 10 turns with a mean diameter 120 mm. The spring carries an axial pull of 200 N. What is the value of shear stress induced in the spring neglecting the effect of stress concentration and of deflection in the spring, when the modulus of rigidity is 80 kN/mm^2?

(A) 63.5 N/mm^2 and 34.6 mm
(B) 54.2 N/mm^2 and 34.6 mm
(C) 63.5 N/mm^2 and 42.6 mm
(D) 54.2 N/mm^2 and 42.6 mm

Key: (A)

Sol: d = 10 mm,
n = 10,
R = 60 mm,
P = 200 N

Shear stress in spring

$$T = \frac{16PR}{\pi d^3} + \frac{4P}{\pi d^2} = 63.5\,N/mm^2$$

Deflection of spring $\Delta = \frac{64PR^3n}{Gd^4}$

$$\therefore \Delta = \frac{64 \times 200 \times 60^3 \times 10}{80 \times 10^3 \times 10} = 34.6mm$$

47. Consider the following statements for a thick-walled cylinder, subjected to an internal pressure:

1. Hoop stress is maximum at the inside radius.
2. Hoop stress is zero at the outside radius.
3. Shear stress is maximum at the inside radius.
4. Radial stress is uniform throughout the thickness of the wall.

Which of the above statements are correct?

(A) 1 and 4 (B) 1 and 3
(C) 2 and 3 (D) 2 and 4

Key: (B)

Sol: For thick cylinder

- Hoop stress is max at inner surface and min at outer surface, varying hyperbolic.
- Radial stress is max at inner surface and zero at outer surface, varying hyperbolic.
- Maximum shear stress will occur at inner radius since Hoop stress is tensile and radial stress is compressive in nature.

48. A helical spring of 10 N/mm rating is mounted on top of another helical spring of 8 N/mm rating. The force required for a total combined deflection of 45 mm through the two springs is

(A) 100 N (B) 150 N
(C) 200 N (D) 250 N

Key: (C)

Sol: $\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$

$\therefore K_{eq} = \frac{10 \times 8}{10 + 8} = 4.44 N/mm$

Now $\Delta = \frac{F}{K_{eq}} \quad \therefore F = 200N$

49. In waiting line problems if the arrivals are completely random, then the probability distribution of number of arrivals in a given time follows a/an

(A) Poisson distribution
(B) normal distribution
(C) exponential distribution
(D) binomial distribution

Key: (A)

Sol: The simplest arrival process is one where we have completely regular arrivals (i.e. the same constant time interval between successive arrivals). A Poisson stream of arrivals corresponds to arrivals at random.

50. Measured mechanical properties of material are same in a particular direction at each point. This property of the material is known as

(A) isotropy (B) homogeneity
(C) orthotropy (D) anisotropy

Key: (B)

51. A long column hinged at both the ends has certain critical Euler's buckling load-carrying capacity. If the same column be fixed at both the ends (in place of hinged ends), the load-carrying capacity then increases to

(A) 4 times (B) 3 times (C) 2 times (D) Nil

Key: (A)

Sol: $P_e = \frac{\pi^2 E I_{min}}{L_e^2}$

For both end fixed support $L_e = \frac{L}{2}$ for both end hinge support $L_e = L$

$\therefore P_{e \text{ both end fixed}} = 4P_{e \text{ both end hinged}}$

52. The strain energy per unit volume of a round bar under uniaxial tension with axial stress σ and modulus of elasticity E is

(A) $\frac{\sigma^2}{E}$ (B) $\frac{\sigma^2}{2E}$ (C) $\frac{\sigma^2}{3E}$ (D) $\frac{\sigma^2}{4E}$

Key: (B)

Sol: Strain energy / volume = $\frac{1}{2}.\sigma.\in = \frac{\sigma^2}{2E}$

53. A steel hub of 100 mm internal diameter and uniform thickness of 10 mm was heated to a temperature of 300 °C to shrink fit it on a shaft. On cooling, a crack developed parallel to the direction of the length of the hub. The cause of the failure is attributable to

(A) tensile hoop stress
(B) tensile radial stress
(C) compressive hoop stress
(D) compressive radial stress

Key: (A)

Sol: (i) Generally in pressure vessels, Hoop stresses are the maximum tensile stresses.

(ii) Crack propagates in direction perpendicular to direction of maximum tensile stress.

54. Consider the following statements:
A characteristic of the structure of metallic atoms is that

1. their outermost orbital of electrons is nearly complete and they attract electrons from other atoms
2. their atoms are smaller and more compact than those of non-metallic elements

Which of the above statements is/are correct?

(A) 1 only (B) 2 only
(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (A)

55. Spark sintering is a kind of hot pressure shaping technique in which

(A) the arc is produced inside the mould
(B) the electrical heating of metallic powders by the production of spark in a graphite die is for a short time under pressure
(C) before passing through the extrusion dies, a constant spark is produced
(D) None of the above is applicable

Key: (B)

56. The capacity of a material to absorb energy when deformed elastically and then to have this energy recovered upon unloading is called

(A) endurance (B) resilience
(C) toughness (D) ductility

Key:(B)

57. The recrystallization behaviour of a particular metal alloy is specified in terms of reciystallization temperature, which is typically 1/3rd of the absolute melting temperature of a metal or an alloy and depends on several factors including the amount of

1. cold working and purity of the metal and alloy
2. hot working and purity of the metal and alloy

Which of the above is/are correct?

(A) 1 only (B) 2 only
(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (A)

Sol: Recrystallization temperature depends on the amount of cold work a material has already received. The higher the cold work , the lower would be the recrystallization temperature. Recrystallization temperature varies between 1/3 to 1/2 melting point.

58. Consider the following pairs regarding plastics and their respective characteristics:

1. Polycarbonate: Poor impact resistance
2. PTFE: Low coefficient of friction
3. Polypropylene: Excellent fatigue strength

Which of the above pairs is/are correctly matched?

(A) 1 only (B) 2 only
(C) 1 and 3 (D) 2 and 3

Key: (D)

Sol: Polycarbonates are long-chain linear polyesters of carbonic acid and dihydric phenols. It has high impact-resistance and has low scratch-resistance.
PTFE has one of the lowest coefficients of friction of any solid. PTFE is used as a non-stick coating for pans and other cookware.
Polypropylene, the uniform structures are responsible for good fatigue and wear properties. Out of the given options 3, 1 is incorrect and statements 2 & 3 are correct.

59. Consider the following statements:

1. Heat treatment is effective only in case of certain alloys.
2. Cooling rate is an important factor in any heat treatment process.
3. The temperature at which the change starts on heating the steel is called lower critical temperature.

Which of the above statements are correct?

(A) 1 and 2 only (B) 2 and 3 only
(C) 1 and 3 only (D) 1, 2 and 3

Key: (D)

60. Consider the following processing methods for plastics:

1. Transfer moulding
2. Extrusion
3. Thermoforming
4. Calandering

Which of these are best suited for processing of plastics to their final shape?

(A) 1, 2 and 3 only (B) 1, 2 and 4 only
(C) 3 and 4 only (D) 1, 2, 3 and 4

Key: (B)

Sol: Thermoforming is, at its core, the process of taking a sheet of plastic material, heating it up until its pliable, and forming it to a three-dimensional shape, then trimming and finishing it into a usable product. Thus, Thermoforming usually requires trimming process to obtain final shape product. Calendaring on the other hand is finishing process.

61. A reaction-bonded silicon nitride ceramic has a strength of 300 MPa and a fracture toughness of 3.6 MPa $\sqrt{m}$. With y = 1 the fracture toughness equation, what is the largest size of internal crack that this material can withstand without fracturing?

(A) 91.6 μm (B) 82.3 μm
(C) 74.6 μm (D) 45.8 μm

Key: (D)

Sol: $K = Y\sigma\sqrt{\pi a}$

Where;

K - stress intensity or Fracture Toughness

Y - geometry dominated factor known as the stress intensity factor

σ - tensile stress opening the crack

a - crack length

$3.6 = 1 \times 300 \times \sqrt{\pi \times a}$

$a = 45.8\mu m$

62. The modulus of elasticity of E-glass is 72 GPa and that of epoxy resin is 3 GPa. The modulus of elasticity (to the nearest unit magnitude) for a composite material consisting of 60% by volume of continuous E-glass fibre and 40% epoxy resin for the matrix, when stressed under isostress conditions, is

(A) 4 GPa (B) 5 GPa
(C) 6 GPa (D) 7 GPa

Key: (D)

Sol: For isostress condition,

$$E_c = \frac{E_m E_f}{E_m V_f + E_f V_m} = \frac{72 \times 3}{(3 \times 0.6) + (72 \times 0.4)}$$

$= 7GPa$

where,

E_c = Young's modulus of Composite

E_m = Young's modulus of matrix

E_f = Young's modulus of fibre

V_m = Volume fraction of matrix

V_f = Volume fraction of fibre

63. In developing abrasive ceramics which are used to wear, grind or cut away other materials which are (necessarily) softer, they should have, besides wear resistance,

1. a high degree of toughness
2. a low degree of toughness
3. refractoriness

Which of the above is/are correct?

(A) 1 only (B) 2 only
(C) 1 and 3 (D) 2 and 3

Key: (C)

64. Consider the following in case of high-energy forming processes:

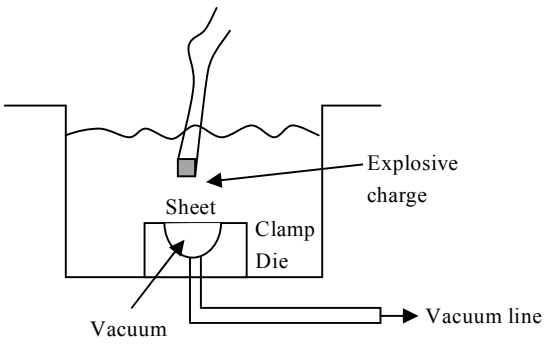
1. The evacuation between die and blank in explosive forming is done by a vacuum pump.
2. The pressure waves produced in water in explosive forming deform the blank to the die shape.
3. The electrohydraulic forming makes use of discharge of large amount of electrical energy used in a capacitor bank.
4. In Petroforge, the piston is moved by combustion of fuel moving at the rate of 150-200 m/s.

Which of the above are correct?

(A) 1, 2, 3 and 4 (B) 1, 2 and 3 only
(C) 3 and 4 only (D) 1, 2 and 4 only

Key: (A)

Sol: In electrohydraulic forming:



A capacitor bank is charged through the charging circuit, subsequently, a switch is closed, resulting in a spark within the electrode gap to discharge the capacitors.

Under water explosions:

A shock wave in the fluid medium (normally water) is generated by detonating an explosive charge.

In petroforge, the stored chemical energy of a hydrocarbon, like petrol or diesel is utilized to move the dies at very high velocity. The principle of working of a petro-forge hammer is just similar to I.C. Engine. In piston-cylinder arrangement a piston drives a ram (piston rod) and a die. The velocity energy 150 to 250 m/s.

65. In abrasive jet machining process, the main mechanism of material removal takes place due to

(A) electrochemical action
(B) mechanical impact
(C) fatigue failure of the material
(D) sparking on impact

Key: (B)

Sol: Abrassive particles impact the work surface, they fracture off ether particles also. As the particle impacts the surface, It causes a small fracture in the workpiece, and the gas stream carries both the abrasive particles and the fractured (wear) particles away.

66. Consider that the following materials are usable for manufacturing dies; moulds in investment casting process for the purpose of large-scale production :

1. Aluminium alloy
2. Magnesium alloy
3. Brass
4. Low-carbon steel

Which of the above are correctly usable?

(A) 1, 2 and 3 only (B) 1, 2 and 4 only
(C) 3 and 4 only (D) 1, 2, 3 and 4

Key: (A)

Sol: Aluminium alloy, magnesium alloys, brass are used for manufacturing dies, moulds in investment casting as dies requires high hardness and also like high carbon steels due to high hardness. Low carbon steels will not have enough hardness, thus cannot be used in investment casting process as moulds.

67. The occurrence of casting defect 'rat tail' is possible because of

1. soft ramming of sand
2. continuous large flat surface on the mould
3. excessive hardness of the mould

Which of the above reasons are correct?

(A) 1 and 2 only (B) 2 and 3 only
(C) 1 and 3 only (D) 1, 2 and 3

Key: (D)

Sol: Rat tail casting defect is a long, shallow angular depression on the surface of casting. It is due to soft ramming or excessive hardness of mould which leads to insufficient hot deformation of sand, it may also result due to design problems such as providing large flat surface on the mould.

68. Components produced by die casting have finer grain, higher strength and greater hardness at the skin than at the centre due to

(A) decreased wall thickness of die cavity
(B) rapid chilling of molten metal at the die walls
(C) high temperature involved in the process
(D) high tonnage of die casting machines

Key: (B)

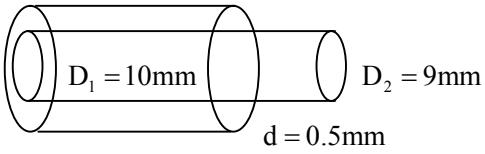
Sol: The size of the grains depends on the rate of solidification of the molten metal. Higher is the solidification rate, finer are the grains. The walls of die casting have a chilling effect, thus producing fine grains that are hard and strong.

69. A 125 mm long, 10 mm diameter stainless steel rod is being turned to 9 mm diameter, 0.5 mm depth of cut. The spindle rotates at 360 r.p.m. With the tool traversing at an axial speed of 175 mm/min, the metal removal rate is nearly

(A) 2200 mm^3/min (B) 2400 mm^3/min
(C) 2600 mm^3/min (D) 2800 mm^3/min

Key: (C)

Sol: $F = \overline{fN} = 175\text{mm/min}$



MRR = cross section ×axial velocity

$$= \frac{\pi}{4}\left(D_1^2 - D_2^2\right) \times F$$

$$= \frac{\pi}{4}\left(10^2 - 9^2\right) \times 175\text{mm}^3/\text{min}$$

$$= 2611.45\text{mm}^3/\text{min}$$

70. The feed in face milling for a width of 70 mm with a cutter of 160 mm diameter, having 10 inserts and rotating at 360 r.p.m., with a feed rate of 0.5 m/min, is nearly
(A) 0.21 mm/tooth (B) 0.18 mm/tooth
(C) 0.14 mm/tooth (D) 0.11 mm/tooth

Key: (C)

Sol: $f_t\left(\text{feed per tooth}\right) = \frac{f_m}{N_z} = \frac{0.5 \times 10^3}{360 \times 10}$

$= 0.138 \sim 0.14\text{mm/tooth}$

71. A lathe consumes 500 W when running idle and 2500 W when cutting a steel specimen at 30 m/min. If the depth of cut is 4 mm and feed rate is 0.25 mm/rev, the cutting force and the approximate value of torque at a spindle run of 120 r.p.m. will respectively be
(A) 4000 N and 160 N-m
(B) 3000 N and 160 N-m
(C) 4000 N and 100 N-m
(D) 3000 N and 100 N-m

Key: (A)

Sol: $P_{eff} = 2500 - 500 = 2000\text{W}$

$F \times V = P_{eff}$

$V = \frac{30}{60} = 0.5\text{ m/s}$

$F = \frac{2000}{0.5} = 4000\text{N}$

$D = \frac{V}{\pi N} = \frac{30}{3.14 \times 120} = 0.08\text{m}$

$r = 0.04\text{m}$

$\text{Torque} = 4000 \times 0.04 \Rightarrow T = 160\text{N} - \text{m}$

72. For a shaper, the length of stroke is 210 mm, the number of double strokes per minute is 32 and the ratio of return time to cutting time is 2 : 3. The cutting speed will be
(A) 8.1 m/min (B) 11.2 m/min
(C) 14.3 m/min (D) 17.4 m/min

Key: (B)

Sol: $V = \frac{LN\left(1+\lambda\right)}{1000} = \frac{210 \times 32 \times \left(5/3\right)}{1000}$

$= 11.2\text{m/min}$

73. The headstock of a lathe has 9 speeds with minimum speed of 100 r.p.m. and maximum speed of 1600 r.p.m. If the speeds are in geometric progression, then the ratio is
(A) 1.06 (B) 1.22 (C) 1.41 (D) 1.64

Key: (C)

Sol: $N_{max} = N_{min}\left(r\right)^{n-1}$

$1600 = 100\left(r\right)^8 \Rightarrow r = 16^{1/8} = 1.414$

74. Surface cracking occurring at low temperatures in hydrostatic extrusion is known as
(A) fluid defect
(B) bamboo defect
(C) fishtailing
(D) arrowhead fracture

Key: (B)

Sol: Surface crack may occur at low temperature and has been attributed to periodic sticking of the extruded product along the die land (stick-slip) during extrusion. When the produce being extruded sticks to the die land, the extrusion pressure increases rapidly, shortly the reafter, the product moves forward again, and the pressure is released. The cycle is then repeated because of its appearance, this defect is known as a bamboo defect.

75. Flank wear occurs mainly on the
1. nose part of the cutting tool
2. front relief face and side relief face of the cutting tool
3. face of the cutting tool at the shortest distance from the cutting edge

Which of the above is/are correct?

(A) 1 and 2 (B) 1 and 3
(C) 2 only (D) 1 only

Key: (A)

Sol: Flank wear occurs mainly on nose part, front relief face, and relief face of the cutting tool.

76. A part programme for any arbitrary object is given as follows:

N001	G91	G71	M03	S600	EOB
N002	GOO	X 10.00	Y10.00		EOB
N003	GOO	Z-10.00			EOB
N004	G83	Z-60.00	F100		EOB
N005	G80				EOB
N006	M02				EOB

The above programming format will be used as Canned cycle for

(A) Drilling (B) tapping
(C) boring (D) grooving

Key: (A)

Sol: G81 - Drill cycle
G82 - Counter bore cycle
G83 - Deep hole drilling cycle

77. In case of TIG welding of aluminium alloys, the amount of shielding gas used can be determined from the band of white deposit (aluminium oxide) alongside of the weld bead.

A hairline width white band indicates that the quantum of shielding gas used has been

1. more them required
2. lesser than required
3. adequate as required

Which of the above is correct?

(A) 1 (B) 2 (C) 3
(D) Cannot be determined due to insufficient information

Key: (C)

Sol: In TIG welding of aluminum alloys, a band of white deposit appears alongside weld bead which on chemical analysis revealed it as aluminum oxide and is believed to be caused by emission of electrons from surface of aluminum (negative cathode). Electrons detach the oxide from the surface as they fly off. When deposit band is of hairline width, it indicates shielding is just adequate.

If the band is wider, it means that the gas flow is too much and gas is being wasted.

78. If H is the heat input, l is the weld length, V is the voltage applied, I is the current, v is the welding speed and e is the efficiency of the process, then the process-governing equation in arc welding is given by

(A) $\frac{H}{I} = e\frac{VI}{v}$ (B) $\frac{H}{v} = e\frac{VI}{\ell}$

(C) $H = e\frac{VI}{v\ell}$ (D) $H = eVI.v\ell$

Key: (A)

Sol: 'H' is input heat in 'Joules' i.e., output of the applied input 'VI' in 'Watts'. Time of operation is 'l/v' in 'seconds'. So, efficiency

$$e = \frac{\text{heat input to welding}}{\text{Applied electric input}} = \frac{\left(H/\text{Time}\right)}{VI} = \frac{\left(\frac{Hv}{\ell}\right)}{VI}$$

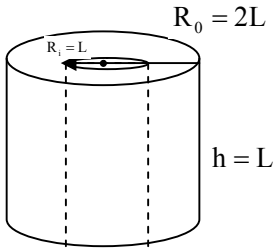
$$\Rightarrow \frac{H}{\ell} = e\frac{VI}{v}$$

79. A Cylindrical Robot can reach any point in a cylinder of height L and radius 2L, except for the points in an inner cylinder of height L and radius L. The volume for the Cylindrical Robot work envelope will be

(A) $9.42L^3$ (B) $6.24\ L^3$
(C) $9.12\ L^3$ (D) $9.86\ L^3$

Key: (A)

Sol: $\text{Volume} = \pi\left(R_0^2 - R_i^2\right) \times h$



$$= \pi\left\{(2L)^2 - L^2\right\} \times L$$

$$= \pi \times 3L^3 = 9.42L^3$$

80. Consider the following statements about forging:
1. Forgings have high strength and ductility.
2. Forgings offer great resistance to impact and fatigue loads.
3. Forging assures uniformity in density as well as dimensions of the forged parts.

Which of the above statements are correct?
(A) 1 and 2 only (B) 1 and 3 only
(C) 2 and 3 only (D) 1, 2 and 3

Key: (C)

Sol: Forgings have high strength and reduced ductility due to work hardening. Forging have high impact and fatigue strength as well. Statement 1 is incorrect. So, options a, b and d are incorrect. In Warm forging of steel, narrower tolerances are achievable than in hot forging. In Cold forging of steel, (highly) narrow tolerances achievable.

81. In a machining test, a cutting speed of 100 m/min indicated the tool life as 16 min and a cutting speed of 200 m/min indicated the tool life as 4 min. The values of n and C are
(A) 0.5 and 200 (B) 0.25 and 200
(C) 0.5 and 400 (D) 0.25 and 400

Key: (C)

Sol: $V_1T_1^n = V_2T_2^n = C$

$100 \times 16^n = 200 \times 4^n = C$

or $n = \frac{1}{2} = 0.5$

or $C = 100 \times 16^{0.5} = 400$

82. Which of the following Robots has application for mobile platform handling in cockpit flight simulators?
(A) SCARA Robot
(B) Articulated Robot
(C) Parallel Robot
(D) Cylindrical Robot

Key: (C)

Sol: Parallel Robot:
One use is a mobile platform handling cockpit flight simulators. It's a robot whose arms have concurrent prismatic or rotary joints.

83. What is the degree of operating leverage in the following cases?
1. Where profit is 5,00,000 and total fixed cost is 4,00,000
2. Where 1% increase in output brings in 3% increase in profit

(A) 0.8 and 3 (B) 1.5 and 3
(C) 0.8 and 4 (D) 1.5 and 4

Key: (B)

Sol: 1. Degree of Operating Leverage (DOL) indicates the expected response in profits if sales volumes change. It is percentage change in income divided by the percentage change in the level of sales output.

$$DOL = \frac{Q(P-V)}{Q(P-V)-F}$$

Q = Quantity or Sold
V = Variable cost per unit
P = Sales price
F = Fixed operating costs

$\text{Profit (Pro)} = QP - (F + VQ);$

$Q(P-V) = \text{Pro} + F$

$\Rightarrow DOL = (\text{Pro} + F)/(\text{Pros})$

$= (500000 + 400000)/(500000) = 1.8$

This implies maximum DOL of 1.8 is expected which shows it can be any value less than equal to 1.8. As DOL should be greater than 1 for better operation. So options (A) and (C) can be eliminated where DOL(0.8)<1. From the options 1.5 seems reasonable option which is greater than 1 and less than 1.8. In simple words, Positive Profit implies DOL>1.

2. Operating leverage is ratio of Percentage increase in profit to Percentage increase in output or sales volume=3/1=3

84. The input variables of EDM Under a given combination of electrode (tool), dielectric and workpiece are
(A) surface finish and metal removal rate
(B) frequency of current and surface finish
(C) amperage and frequency
(D) metal removal rate and amperage

Key: (C)

Sol: Input parameters or variables in EDM process are amperage and frequency of pulses, while the output parameter are metal removal rate, wear and surface finish.

85. During the formation of chips in machining with a cutting tool, which one of the following relations holds good?

(A) $\frac{V}{\cos(\phi-\alpha)}=\frac{V_S}{\cos\alpha}=\frac{V_C}{\sin\alpha}$

(B) $\frac{V}{\sin(\phi-\alpha)}=\frac{V_S}{\cos\alpha}=\frac{V_C}{\sin\alpha}$

(C) $\frac{V}{\cos\alpha}=\frac{V_C}{\sin\alpha}=\frac{V_S}{\sin(\phi-\alpha)}$

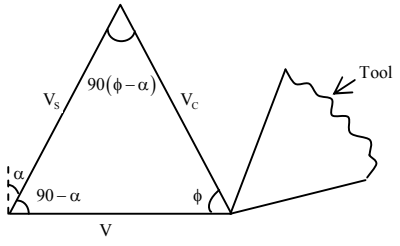
(D) $V\cos\alpha = V_C\sin\alpha = V_S\cos(\alpha-\phi)$

where V is the cutting speed, V_C is the velocity of the chip, V_S is the velocity at which shearing takes place along the shear plane, ϕ is the shear angle and α is the rake angle.

Key: (A)

Sol: $\frac{V}{\sin\{90-(\phi-\alpha)\}}=\frac{V_C}{\sin\alpha}=\frac{V_S}{\sin(90-\alpha)}$

or $\frac{V}{\cos(\phi-\alpha)}=\frac{V_C}{\sin\phi}=\frac{V_S}{\cos\alpha}$



86. The complexity of a jig or a fixture is determined by

1. the number of pieces that must be produced

2. the degree of accuracy required

3. the number and kind of machining operations that must be performed

Which of the above are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

Sol: The design of a jig and a fixture depends on production rate, type of operations and the finish required.

87. For a small-scale industry, the fixed cost per month is 5,000. The variable cost per product is 20 and the sales price is 30 per piece. The break-even production per month will be

(A) 300 (B) 400 (C) 500 (D) 600

Key: (C)

Sol: $Q=\frac{F}{S-V}=\frac{5000}{30-20}=500$

88. Coriolis component of acceleration depends on

1. angular velocity of the link
2. acceleration of the slider
3. angular acceleration of the link

Which of the above is/are correct?

(A) 1 only (B) 2 only

(C) 1 and 3 (D) 2 and 3

Key: (A)

Sol: Coriolis acceleration $a_c = 2VW$

Depends upon angular velocity

89. Which one of the following distributions provides information regarding the uncertainty of duration time estimates in PERT described network?

(A) Beta-distribution

(B) Normal distribution

(C) Poisson distribution

(D) Binomial distribution

Key: (A)

Sol: It is based on three time estimates namely 'pessimistic time', 'optimistic time' and 'most likely time'. If conditions are certain and normal , one time estimate is enough but during uncertainty of time duration we need more than one time estimate as incorporated by Beta distribution.

90. When an ordering cost is increased to 4 times, the EOQ will be increased to

(A) 2 times (B) 4 times

(C) 8 times (D) 16 times

Key: (A)

91. The weekly sale for tin item is A units. The ordering cost per order is B rupees. The carrying cost per unit per month is C rupees. The EOQ (with a year of 52 weeks as the basis) will nearly be

(A) $\sqrt{\frac{8.7A}{BC}}$ (B) $\sqrt{\frac{8.7AB}{C}}$

(C) $\sqrt{\frac{4.35A}{BC}}$ (D) $\sqrt{\frac{4.35AB}{C}}$

Key: (B)

Sol: $Q = \sqrt{\frac{2 \times 52 \times A \times B}{12 \times C}} = \sqrt{\frac{8.7AB}{C}}$

92. A self-service store employs one cashier at its counter. 8 customers arrive on an average every 5 minutes, whereas cashier can serve 10 customers in same time. Assuming Poisson distribution for service rate, the average time a customer spends in the queue will be

(A) 4 minutes (B) 3 minutes

(C) 2 minutes (D) 1 minute

Key: (C)

93. In an internally pressurized thick cylinder, the hoop stress

1. remains constant but the radial stress varies parabolically

2. varies parabolically but the radial stress remains constant

Which of the above is/are correct?

(A) 1 only (B) 2 only

(C) Both 1 and 2 (D) Neither 1 nor 2

Key: (D)

Sol: For internally pressurized thick cylinder

- Hoop stress is max at inner surface and min at outer surface, varying hyperbolic.
- Radial stress is max at inner surface and zero at outer surface, varying hyperbolic.

94. Consider the following statements for down-milling operation :

1. The workpiece is forced against the holding device by the cutter.

2. The cutting tool rotates in the same direction.

3. Backlash elimination is not required.

4. The cut starts with a full chip thickness.

Which of the above statements are correct in this context?

(A) 1, 2 and 3 only (B) 3 and 4 only

(C) 1, 2 and 4 only (D) 1, 2, 3 and 4

Key: (C)

Sol: In a down milling operation:

1. Cutter rotates in same direction as movement of work piece.
2. Thickness of cut is maximum at the start of engagement.
3. The cutter forces work piece against the holding device.
4. Backlash elimination is a must in down milling and required

95. Consider the following functions regarding production control department :

1. Provision of resources

2. Preparation of production schedules

3. To maintain the requisite quality standards

Which of the above functions are correct?

(A) 1 and 2 only (B) 1 and 3 only

(C) 2 and 3 only (D) 1, 2 and 3

Key: (D)

Sol: The American Production and Inventory Control Society, (APICS), defined production control in 1959 as: "Production control is the task of predicting, planning and scheduling work, taking into account manpower, materials availability and other capacity restrictions, and cost so as to achieve proper quality and quantity at the time it is needed and then following up the schedule to see that the plan is carried out, using whatever systems have proven satisfactory for the purpose."

Underlined parts are analogous to 1, 2 and 3 (not in same order) given.

96. Auditing of the measurement systems establishes:

1. whether they are informing enough for decision making
2. whether the cost of data collection is merited

3. whether measurements are being taking accurately

Which of the above functions are correct?
(A) 1 and 2 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

Key: (B)

Sol: Main aim of auditing of measurement system is to establish accuracy of measurements and whether they are enough to take a decision but not related to cost meriting/highlighting. This is due to the reason that even after collecting data at high or low cost it should be available to all stake holders for free consultation and use which means system should not hamper any one to retrieve and use due to cost.

97. Consider the following statements with respect to flow diagram in work study :
1. Movement of machines is drawn in flow diagram.
2. Movement of men is drawn in flow diagram.
3. In flow diagram, all movements are drawn true to scale.

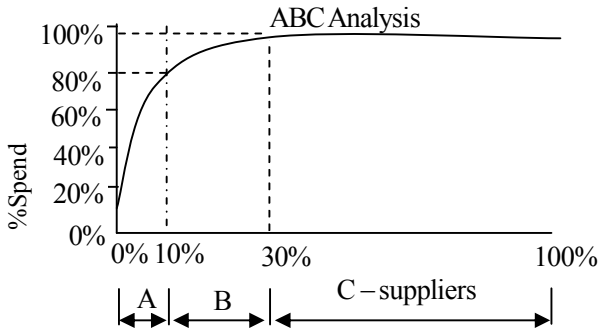
Which of the above statements are correct?
(A) 1 and 2 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

Key: (C)

98. An organization uses ABC approach for categorization of its stock. Which of the following describe class C items?
(A) High value and high risk
(B) High value and low risk
(C) Low value and high risk
(D) Low value and low risk

Key: (D)

Sol: In ABC analysis, A class items are high value and high risk accounting for 70% usage value, B class items are medium usage value of 20% and C class items are low value of 10% and low risk.



99. Consider the following elements of situation awareness :
1. Perception of elements in the environment within a volume of time and space, comprehension of their meaning and projection of their status in the future
2. Perception of elements in the environment within a volume of time and space, comprehension of their meaning, projection of their status in the future and interpretation of the results
3. Sensing of the elements in the environment, perception of those elements, analysis of consequences, projection of alternative outcomes and interpretation of the results

Which of the above is/are correct?
(A) 1 only (B) 1 and 2
(C) 2 and 3 (D) 3 only

Key: (C)

100. In case of design of friction clutches, uniform rate of wear theory is used over uniform pressure. The reasons may be the following:
1. It gives higher frictional torque.
2. It gives lower frictional torque.
3. The intensity of pressure is maximum at the inner radius and minimum at the outer radius of the friction or contact surfaces.
4. This concept is prevalent for running and old clutches.

Which of the above reasons are correct?

(A) 1, 3 and 4 (B) 1 and 3 only

(C) 2 and 3 (D) 2 and 4

Key: (A)

Sol: For the given dimensions of the clutch, the torque transmitted will be less according to uniform wear theory than according to uniform pressure theory since mean friction radius in uniform wear theory $\left(\frac{\mu(r_1+r_2)}{2}\right)$ is less then mean friction radius in uniform pressure theory $\left(\mu\frac{2}{3}\frac{(r_1^3-r_2^3)}{r_1^2-r_2^2}\right)$. Hence to be on more safe side we will use uniform wear theory for design of friction clutches. So statement '2' is correct.

This concept of uniform wear theory is prevalent (widely accepted) for running and old clutches. Means that the torque obtained from uniform wear theory is almost matching with the actual torque transmitted by running and old clutches. Hence this theory is used for design of friction clutches. So statement '4' is correct.

Directions: Each of the following twenty (20) items consists of two statements, one labeled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the code given below.

Code:

(A) Both Statement (I) and Statement (II) are individually true and Statement (II) is the correct explanation of Statement (I).

(B) Both Statement (I) and Statement (II) are individually true but Statement (II) is not the correct explanation of Statement (I).

(C) Statement (I) is true but Statement (II) is false.

(D) Statement (I) is false but Statement (II) is true.

101. Statement (I): Automated guided vehicle (AGV) is a programmable mobile vehicle without human intervention and used for material handling.

Statement (II): Automated storage and retrieval system (AS/RS) is a part of CNC machine and used for machining operation.

Key: (B)

Sol: AGV:

These are battery powered, driverless vehicles for automatic transport of parts and tooling on the shop floor.

These moves on fixed paths laid underneath the factory floor, and transport materials from the workstation to storage locations, load stations, etc.

Automated storage and retrieval system (AS/RS) is needed for CNC machine tooling.

In the tool magazine a particular tool to be use and after use that should be placed in that location again.

102. Statement (I): The follower motion represented on the displacement diagram is achieved by proper cam profile.

Statement (II): The cam profile is constructed using the principle of kinematic inversion.

Key: (A)

103. Statement (I): Composite material is combination of two or more chemically unlike materials.

Statement (II): Composite materials have their own specific properties and are different from their individual material properties.

Key: (B)

104. Statement (I): The epicyclic gear train has a central gear and an epicyclic gear which produces epicyclic motion being moved by a crank arm.
Statement (II): The arm contains the bearings for the epicyclic gear to maintain two gears in mesh.

Key: (B)

105. Statement (I): Two non-intersecting and non-parallel, i.e., non-coplanar, shafts connected by gears are called skew-bevel gears or spiral gears, and this type of gearing has a line contact, the rotation of which about the axes generates the two hyperboloid pitch surfaces.
Statement (II): A hyperboloid is a 3D surface formed by revolving a straight line about an axis (not in the same plane), such that every point on the line remains at a constant distance from the axis.

Key: (C)

106. Statement (I): Motor vehicles have differential gear mechanism at the back axle.
Statement (II): This mechanism is fitted to enable the vehicles to run on bumpy roads.

Key: (C)

Sol: Differential gear mechanism will be used in motor vehicles at the back axle to run the two back wheels at different speeds and while taking a turn. Hence statement-I is correct and statement-II is not correct.

107. Statement (I): The distribution of mass along the axis of rotation of a shaft depends on the configuration of the part.
Statement (II): All mass centres must fall on straight line parallel to the axis of the shaft for complete dynamic balancing.

Key: (C)

108. Statement (I) : In resistance welding of sheet metal, filler rod is not used.
Statement (II) : It is the filler rod which gets oxidized and deposits the oxide in the weldment.

Key: (C)

Sol: Resistance welding is an autogenous welding procedure which does not require filler rod and the metal is melted by resistive heating. In other process, use of filler materials other than base metal may load to formation of galvanic couples leading to weld corrosion. Here filler is not needed so there is not possibility of statement II.

109. Statement (I): The linear speed of the belt in a belt drive is controlled by the tensile strength of the material of the driven pulley (larger in diameter).
Statement (II): The rotating pulley rim is subjected to tensile hoop stress.

Key: (D)

Sol: Linear speed of the belt is not function of tensile strength of the pulley material...it is controlled by angular velocity of pulley and diameter of pulley. The safe maximum speed of belt is function of tensile strength of belt but not pulley.
Since centrifugal force is radially outward and tends to expand circumference of rim, the rim of pulley certainly carries tensile hoop stress.

110. Statement (I): In an epicyclic gear train, the size of the gearbox is smaller than that of the spur gearbox for the same horsepower and the same velocity ratio.
Statement (II): In an epicyclic gearbox, more than one pair of gear pinion contacts always exist, whereas it is not so in spur gearbox.

Key: (A)

Sol: Both statements I and statement II are correct. Statement II gives correct explanation of statement I.

In an epicyclic gearbox, more than one pair of gear pinion contacts always exist which allows distribution of load per tooth and reduction of size of gears which ultimately leads to reduction of size.

111. Statement (I): Pursuant to plastic deformation of metals, the mechanical properties of the metals get changed.

Statement (II): Mechanical properties of metals depend on grain size also which gets changed by plastic deformation.

Key: (A)

Sol: Mechanical properties of material depends on grain size.

Due to plastic deformation grain gets elongated.

112. Statement (I): In quick return motion mechanism, Coriolis acceleration exists.

Statement (II): Two links in this mechanism oscillate with one sliding relative to the other.

Key: (C)

113. Statement (I): Ceramics withstand very high temperatures that range from 1000°C to 1600°C.

Statement (II): Silicon carbide is an exception from among ceramics that cam withstand high temperatures.

Key: (B)

Sol: Creamics tool is used upto 1300°C, SiC can with stand upto 2700°C, so we can use it for furnace part. Hence statement-I and statement-II has no relation.

114. Statement (I): Employing the extrusion process is not economical in case of large billets.

Statement (II): A significant part of the press capacity is lost overcoming frictional resistance between workpiece and cylinder wall during the extrusion process.

Key: (A)

Sol: In the direct extrusion a significant amount of energy is used to overcome frictional resistance between workpiece and cylinder wall.

115. Statement (I): In drop forging, the excess metal added to the stock for complete filling of the die cavity is called flash.

Statement (II): Flash acts as a cushion against impact blows attributable to the finishing impression.

Key: (A)

Sol: Yes, flash acts as a cushion but it is not reason for giving flash.

- The excess metal added to the stock to ensure complete filling of the die cavity in the finishing impression is called flash.
- A flash acts as a cushion for impact blows from the finishing impression and also helps to restrict the outward flow of metal, thus helping in filling of thin ribs and bosses in the upper die.

116. Statement (I): In wire-drawing, the end of the stock is made 'pointed' to make for easier entrance of the wire into the die.

Statement (II): The pointing of the wire is done exclusively by rotary swaging and not by simple hammering.

Key: (C)

Sol: In wire drawing, the end of stock is made pointed to facilitate entry into the die. This pointed end can be made by simple hammering or rotary swaging.

117. Statement (I): Metal powders can be produced by atomization process.
Statement (II): In case of metals with low melting point, the size of particles cannot be controlled and the shape of the particles remains regular in atomization.

Key: (C)

Sol:
- Molten metal is forced through a small orifice and is disintegrated by a jet of compressed air, inert gas or water jet.
- In atomization, the particles shape is determined largely by the rate of solidification and varies from spherical, if a low-heat-capacity gas is employed, to highly irregular if water is used. By varying the design and configurations of the jets pressure and volume of the atomizing fluid, thickness of the stream of metal, etc, it is possible to control the particle size distribution over a wide range.

118. Statement (I): In shell moulding process, phenol formaldehyde is never used.
Statement (II): The resins used in this process are basically of the thermoplastic variety.

Key: (D)

Sol: The resins most widely used in shell molding process are phenol formaldehyde resins which have excess phenol and act as thermoplastic material. In order to impart thermosetting properties, a catalyst hexa-methylene-tetramine is mixed with resin.

119. Statement (I): Both sand and metal moulds can be used for centrifugal casting.
Statement (II): In this process, sand moulds are recommended when chilling tendency is to be prevented.

Key: (A)

Sol: Both statements are correct. And statement II is correct reason also for statement I. When cast metal tends to wet mould surfaces, moulds are also made of graphite. Sand moulds are recommended when chilling is to be prevented. For instance when number of castings is small or when casting is long, its typical shape requiring destruction of mould for extracting the casting undamaged.

120. Statement (I): In gas welding process, neutral flame is the most common flame used for welding and cutting stainless steel.
Statement (II): Neutral flame has tendency to react with stainless steel being welded.

Key: (C)

Sol: Neutral flame is mostly used for welding and cutting Stainless Steel. A neutral flame is used to weld stainless steel as it does not react with steel. So, statement I is correct and statement II is incorrect.