IES MASTER
Institute for Engineers (IES/GATE/PSUs)

ESE-2016

Detailed Exam Solutions
(Objective Paper-II)
Mechanical Engineering

In case there is any kind of discrepancy in solutions please write to us at ***ies_master@yahoo.co.in*** or call us at : **Ph: 011-41013406, 09711853908** for rectification/deletion/updation of the same.

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SCROLL DOWN

Explanation of Mechanical Engg. Objective Paper-II (ESE - 2016)

SET - B

1. 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

Ans. (a)

Sol. Endurance limit is the maximum stress level which when applied to a component for infinite number of cycles, will not result in a failure due to fatigue. Fatigue is a failure when a component is subjected to fluctuating stress such as a rotating shaft.

2. 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

Ans. (a)

Sol. For rectangle X-sec. $T_{max} = \frac{3}{2} t_{av}$

3. 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

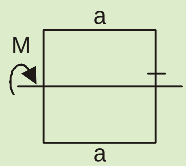
Which of the above is/are correct?

(a) 1 only (b) 2 only

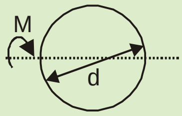
(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (b)

Sol.



Area = a^2 = A, Material is same this means that E is same.



Area $\frac{\pi d^2}{4} = A$

$$I_{rec} = \frac{a^4}{12} = \frac{A^2}{12}$$

$$I_{cir} = \frac{\pi^4}{64} = \frac{\pi}{64} \times \left(\frac{4A}{\pi}\right)^2$$

$$= \frac{16 A^2 \pi}{64 \pi^2} = \frac{A^2}{4\pi}$$

$\Rightarrow$ $I_{cir} < I_{rec}$

Assuming same span length and loading beam having larger moment of inertia will have smaller deflection.

$\Rightarrow$ $\delta_{rec} < \delta_{cir}$

$\Rightarrow$ Statement I is wrong

$$(\text{Flexural stren})_{max} = \frac{My_{max}}{I}$$

For same bending moment, beam having layer $\frac{y_{max}}{I}$ will experience large flexural stress.

$$\left(\frac{y_{max}}{I}\right)_{rec} = \frac{a}{2\times\frac{A^2}{12}} = \frac{\sqrt{A}}{\frac{A^2}{6}} = \frac{6}{A^{\frac{3}{2}}}$$

$$\left(\frac{y_{max}}{I}\right)_{cir} = \frac{d}{2\times\frac{A^2}{4\pi}} = \sqrt{\frac{4A}{\pi}} \times \frac{4\pi}{2A^2}$$

$$= \frac{4\sqrt{\pi}}{A^{\frac{3}{2}}} > \frac{6}{A^{\frac{3}{2}}}$$

$\Rightarrow$ Circulation section experience more flexural stress.

4. 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

Ans. (d)

Sol. When a spring is cut into two parts the stiffness of spring 'k' of each part will become 2k.

When each of them is placed in parallel equivalent stiffness will become 2k + 2k = 4k.

5. 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

Ans. (d)

Sol. Strength of shaft means the maximum torque that can be resulted for a particular max permissible stress.

$$I_{Ra} = \frac{Tr}{J}$$

$$\Rightarrow \quad T = (I_{pa})\frac{J}{r} = I_{per} \times \frac{\pi d^4}{32\times\frac{d}{2}} = \frac{I_{pa}\times\pi}{16} d^3$$

$$\Rightarrow \quad T \;\alpha\; d^3$$

$$\frac{T_B}{T_A} = \left(\frac{dB}{dA}\right)^3 = \left(\frac{100}{50}\right)^3 = 8$$

6. 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

Ans. (a)

The shear stress due to twisting of wire and direct load,

$$\tau = \frac{8WD}{\pi d^3} + \frac{4W}{\pi d^2}$$

$$= \frac{8\times200\times0.12}{\pi\times(0.01)^3} + \frac{4\times200}{\pi\times(0.01)^2}$$

$$= (61.1155 + 2.546) \times 10^6 \text{N/m}^2$$

$$= 63.66 \text{ N/mm}^2$$

$$\text{Deflection } \delta = \frac{8WD^2n}{Gd^4} = \frac{8\times200\times120^3\times10}{80\times10^3\times10^4}$$

$$= 34.56 \text{ mm}$$

7. 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.

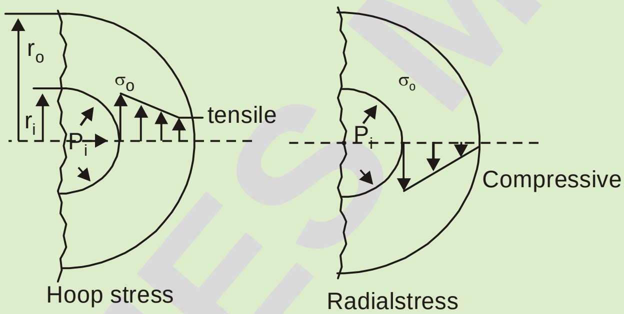
Which of the above statements are correct?

(a) 1 and 4 (b) 1 and 3

(c) 2 and 3 (d) 2 and 4

Ans. (b)

Sol. The distribution of radial and hoop/tangential stress,



Shear stress, $\tau = \left(\frac{\sigma_o - \sigma_r}{2}\right) = \frac{|\sigma_o| - |\sigma_r|}{2}$

Maximum at inner side.

8. 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

Ans. (c)

Sol. The spring are arranged in series, so Equivalent spring rating,

$$K_e = \left(\frac{K_1 \times K_2}{K_1 + K_2}\right) = \frac{10 \times 8}{10 + 8} = \frac{80}{18} = \frac{40}{9} \text{ N/mm}$$

Force to deflect 45 mm,

$$F = K_e \cdot x = \frac{40}{9} \times 45 = 200 \text{ N}$$

9. 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

Ans. (a)

Sol. In waiting line models, arrivals follow poisson distribution where the arrivals are completely random. The service time has an exponential distribution.

10. 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

Ans. (d)

Sol. When mechanical properties of a material are same when measured in a particular direction at each point, this property is called anisotropy. On the other hand, when mechanical properties are same irrespective of direction which they are measured, the property is called isotropy.

11. 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

Ans. **(a)**

Sol. $P_e = \frac{\pi^2 EI_{min}}{L_e^2}$

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

For both end hinged support, $L_e = L$

$\therefore \quad (P_e)_{B.F.} = 4(P_e)_{B.H.}$

12. 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) $\frac{\sigma^2}{4E}$

Ans. **(b)**

Sol. Strain energy/volume

$$= \frac{1}{2} \times \sigma \times E$$

$$= \frac{1}{2} \sigma \times \frac{\sigma}{E} = \frac{\sigma^2}{2E}$$

13. 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

Ans. **(a)**

Sol. In a shrink fit, the hub is subjected to tensile or hoop stress (which is greater as compared to radial stress) and the shaft is subjected to compressive stresses. Therefore, the failure (or crack on surface) is due to tensile hoop stress.

14. 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

Ans. **(b)**

Sol. The outer most orbital of metallic atoms have excess electrons and they donate electrons to other atoms. As compared to non-metals, metals have lesser electrons in an atom and are more compact and smaller.

15. 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

Ans. **(b)**

Sol. Spark sintering or spark plasma sintering is a sintering technique where a dc current passes through the powder compact through a graphite die. The heat is generated through Joule heating. This is a very fast process used to sinter nano material.

16. 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

Ans. **(b)**

Sol. Resilience is the ability of material to absorb strain energy upto elastic limit. This strain energy is released when load is removed.

17. The recrystallization behaviour of a particular metal alloy is specified in terms of recrystallization 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

Ans. **(a)**

Sol. Recrystallization temperature of a metal depends on

(1) Degree of cold working:- Higher the degree of cold working, lower is the recrytallization temperature.

(2) Annealing temperature and

(3) Impurities in metals, higher the impurities, difficult is the process of recrystallization.

(4) High temperature results in faster rerystallization.

18. 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

Ans. **(d)**

Sol. Polycarbonates are thermoplastic polymers mainly used in making eyewear lenses. These have high temperature resistance, impact resistance. PTFE or Teflon has very low coefficient of friction and is used in making bearings. Polypropylene has excellent fatigue strength.

19. 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

Ans. **(d)**

Sol. Heat treatment is effective only in case of certain alloys for example hardening treatment is suitable for high carbon steels only. The cooling rate decides the final microstructure of the alloy. At lower critical temperature, the transformation to austenite begins in steel.

20. Consider the following processing methods for plastics :

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

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

(c) 3 and 4 only (d) 1, 2, 3 and 4

Ans. (b)

Sol. Thermoforming usually requires trimming process to obtain final shape product. Calendaring on the other hand is finishing process.

21. 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

Ans. (c)

Sol. When V_1 = 100m/min; T_1 = 16 min

V_2 = 200 m/min; T_2 = 4 min

Using Taylor boot life equation.

$VT^n = C$

$100 \times (16)^n = C$ and

$200 \times (4)^n = C$

Eliminating C, we get

$100 \times (4)^{2n} = 200 \times (4)^n$

$(4)^{2n} = 2 \times (4)^n = (4)^{1/2} \times (4)^n$

$(4)^{2n} = (4)^{1/2+n}$

$$2n = \frac{1}{2} + n$$

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

also $100 \times (1\ 6)^{1/2}$, $C = 100 \times 4 = 400$

22. 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

Ans. (c)

Sol. A parallel robot has arms with concurrent prismatic or rotary Joints. It is used in mobile platform handling cockpit flight simulators.

23. Which 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

Ans. (a)

Sol. Operating leverage is a measure of how revenue growth translates into income.

$$= \frac{400000}{500000} = 0.8 \text{ or}$$

it is ratio of % change in income to %change in sales (i.e. output)

$$OL = \frac{3\%}{1\%} = 3$$

24. 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

Ans. (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.

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

(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.

Ans. **(a)**

Sol. During machining, the correct relation between velocities is

$$\frac{V}{\cos(\phi-\alpha)} = \frac{V_s}{\cos\alpha} = \frac{V_c}{\sin\phi}$$

None of the option matches the correct relation however option (a) is closest to correct answer.

26. 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 ad 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

Ans. **(d)**

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

27. 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

Ans. **(c)**

Sol. Break even point is given as

$$\text{BEP} = \frac{F}{S-V} = \frac{5000}{30-20} = 500 \text{ units}$$

where F is fixed cost, S is sales price and V is variable cost per piece.

28. 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

Ans. **(a)**

Sol. The expression for Coriolis component of acceleration,

$= 2\ Vw$

where V is sliding velocity of slider over oscillating link and 'w' is angular velocity of oscillating link in quick return mechanism.

29. 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

Ans. **(a)**

Sol. The three time estimates i.e. optimistic, most likely and pessimistic follow the beta distribution in PERT.

30. 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

Ans. (a)

Sol. EOQ or economic order quantity is given as

$$EOQ \cdot \sqrt{\frac{2DC_S}{C_n}}$$

where C_S becomes 4 times, new EOQ is

$$(EOQ)_2 = \sqrt{\frac{2D \times 4C_S}{C_n}} = 2\sqrt{\frac{2DC_S}{C_n}} = 2 \times (EOQ)_1$$

31. The weekly sale for an 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) $\sqrt{\frac{4.35AB}{C}}$

Ans. (b)

Sol. $EOQ = \sqrt{\frac{2DC_S}{C_n}}$

where D is annual demand C_S is ordering cost and C_n is annual holding cost per unit.

Yearly demand D = A × 52

(As there are 52 weeks in a year)

C_n = 12 × C

$$EOQ = \sqrt{\frac{2 \times 52 \times A \times B}{12 \times C}} = \sqrt{\frac{8.67AB}{C}}$$

32. 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

Ans. (c)

Sol. Average time a customer spends in the queue is

$$T = \frac{\lambda}{\mu(\mu - \lambda)}$$

λ = 8 customer/5min or 96/hr

μ = 10 customer/5min or 120 hr

$$T = \frac{96}{120(120-96)} = \frac{964}{120 \times 24} = \frac{1}{30} \text{ hr}$$

or 2 minutes

33. 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

Ans. (d)

Sol. Both hoop stress and radial stress vary parabolically as shown below.

Figure of Q7.

34. 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

Ans. (c)

Sol. In a down milling operation :

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

35. 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

Ans. (a)

Sol. Functions of production control department are:

1. Job scheduling
2. Resource planning
3. Process selection
4. Capacity planning
5. Facility location
6. Machine loading
7. Follow up

36. 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 are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. (b)

Sol. Main aim of auditing of measurement system is to establish accuracy of measurements and whether they are enough to take a decision.

37. 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

Ans. (d)

Sol. Flow diagram indicates movement of men, material and equipment. A flow diagram is drawn to scale to plant layout.

38. 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

Ans. (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.

39. Consider the following elements 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

Ans. (a)

Sol. Situation awareness is perception of elements in the environment with a volume of time and space, comprehension of their meaning and projection of their status in future.

40. 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

Ans. (c)

Sol. Uniform pressure theory gives higher friction torque as compared to uniform wear theory. The uniform wear theory equation,

Pressure (P) Radius(r) = Constant

Hence at minimum radius i.e. inner radius, the pressure is maximum.

Generally old clutch torque capacity is calculated by uniform wear theory and new clutch capacity by uniform pressure theory. The design of new clutches in done by wear theory for safe operation (margin of safety is maintained).

41. 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

Ans. (b)

Sol. Successfully constraint motion means that the motion is constraint only in the presence of external force. The piston inside cylinder executes constraint motion due to it design and gudgeon pin. While foot step bearing requires a force to press the shaft in bearing to have constraint motion (rotation).

42. 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

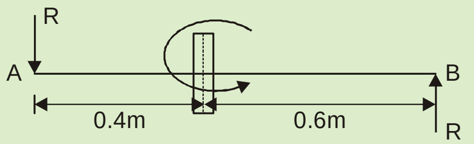
(b) 300 N and 800 N

(c) 800 N and –300 N

(d) 300 N and –300 N

Ans. (d)

Sol. The unbalanced couple is due to dynamic reaction



$\therefore$ Couple, C = $\pm R \cdot l$

$\therefore$ Dynamic reaction, R = $\pm \frac{C}{l}$ = ±300 N

43. 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

Ans. **(d)**

Sol. All given motion of follower impart infinite jerk except cycloidal motion. This motion have jerk but finite magnitude.

44. In a circular are 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

Ans. **(c)**

Sol. The expression for acceleration of follower involve following parameters

(i) Radius of flank of cam surface, 'r_f'

(ii) Least radius of cam profile or base circle radius 'r_b'.

(iii) Radius of roller 'r_r'.

(iv) Cam rotation speed 'ω'

45. 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

Ans. **(d)**

Sol. Breakeven point = $\frac{F}{S-V}$

$$= \frac{50000}{15-10} = \frac{50000}{5}$$

= 10,000 units

46. In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres 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

Ans. **(c)**

Sol. Driving crank length

O_1A = 100 mm

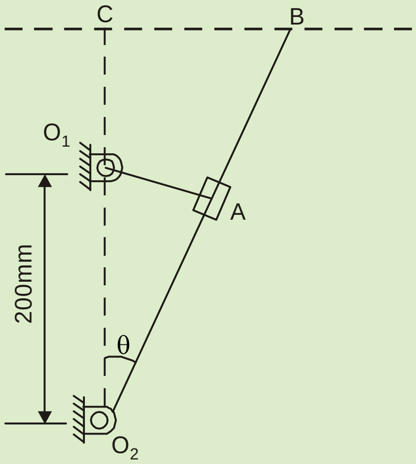
Slotted Bar length

O_2B = 500 mm

$\therefore$ In triangle O_2O_1A

$$\sin\theta = \frac{O_1A}{O_1O_2} = \frac{100}{200}$$

θ = 30°



Length of cutting stroke,

$$= 2BC = 2O_2B\sin\theta = 2\times500\times\sin30$$

$= 2 \times 500 \times 0.5 = 500$ mm

47. 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

Ans. (b)

Sol. PCD of gear = 28 cm

Teeth on gear, $z = 4$

$$\therefore \text{ Circular pitch, } \frac{\pi(\text{PCD})}{z} = \frac{\pi\times280}{40}$$

$= 21.99$ mm

$\simeq$ 22mm/tooth

48. 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

Ans. (a)

Sol. The tooth gears are designed as per law of gearing which states - for constant velocity ratio, the line of action must pass through pitch point which lie on line joining centre of gears.

If this law is not satisfied, the motion transfer will not be proper and there will be impart hitting of teeth meshing gear causing vibration or even drive will jam.

49. 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

Ans. (b)

Sol. The mass moment of flywheel,

$$I = mk^2 = 2000 \times 1^2 = 200 \text{ kg.m}^2$$

The torque applied, $\tau = 2000$ N-m

The angular acceleration,

$$\alpha = \frac{\tau}{I} = \frac{2000}{2000} = 1 \text{ rad/sec}^2$$

Angular velocity,

$$\omega = \omega_0 + \alpha t$$

$$= 0 + 1 \times 10 = 10 \text{ rad/sec}$$

Kinetic energy,

$$= \frac{1}{2}I\omega^2$$

$$= \frac{1}{2} \times 2000 \times 100$$

$= 100$ kJ

50. 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 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

Ans. (b)

Sol.
- In simple gear train, there is only one gear on each shaft. The number of shaft may be any.
- When any shaft have more than one gear (first shaft or second shaft or intermediate shaft i.e. two gear have same angular velocity, the gear drive is called compound gear drive.

51. 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

Ans. (a)

Sol. Power of motor, = 3 kW = 300 W.

Time of rivetting operation t = 1 sec

Energy required by rivetting operation

= 10000 N.m

= 10000 Joule

Energy supplied by motor during rivetting,

$= 3000 \times 1 = 3000$ Joule

Rest of rivetting energy is supplied by flywheel.

$$\Delta E = 10000 - 3000$$

$$\frac{1}{2} I\left(\omega_1^2 - \omega_2^2\right) = 7000 \text{ Joule}$$

where moment of inertia of flywheel,

$$I = mk^2 = 150 \times 0.6^2 = 54 \text{ kg-m}^2$$

Initial angular velocity of flywheel,

$$\omega_1 = \frac{2\pi N_1}{60} = \frac{2\pi \times 300}{60}$$

$= 31.416$ rad/sec

$$\therefore \frac{1}{2} \times 54\left(31.416^2 - \omega_2^2\right) = 7000$$

$$\omega_2^2 = 31.416^2 - \frac{7000}{27} = 727.7$$

$$\omega_2 = 26.97$$

$= 257.6$ rpm

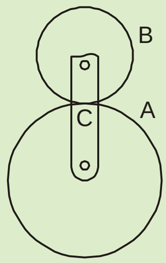
$N_2 = 260$ rpm

Number of rivets per minute,

$$= \frac{\text{Energy supplied by motor per minute}}{\text{Energy for one rivet}}$$

$$= \frac{3000 \times 60}{10000} = 18$$

52. With respect to the epicyclic gear train shown in the figure below, 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

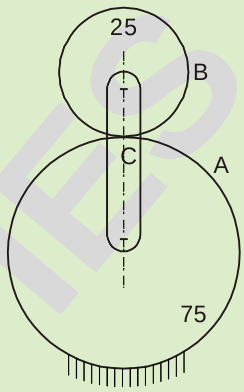
(a) 10 (b) 15

(c) 20 (d) 25

Ans. (c)

Sol. The calculation table

Action	C	A	B
Fix C and x rev. to A	0	x	$-\frac{75}{25}x$ $= -3x$
Add y′ to all	y	$x+y$	$y-3x$



(i) Gear A is fixed,

$\therefore$ $x + y = 0$

$x = -y$

Arm C makes 5-revolution

$\therefore$ $y = 5$

$\therefore$ Revolution of B_1

$y - 3x = y + 3y = 4y = 4 \times 5 = 20$ rev

53. 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

Ans. (b)

Sol. Equation of motion

$$4\frac{d^2x}{dt^2}4\cdot\frac{dx}{dt}+16x=0$$

Standard equation,

$$m\frac{d^2x}{dt^2}+c\frac{dx}{dt}+kx = 0$$

$\therefore$ $m = 4$ kg, $c = q$ N-sec/m

$k = 16$ N/m

$\therefore$ Critical damping

$$C_c = 2\sqrt{k\cdot m} = 2\sqrt{16\times 4}$$
$$= 2 \times 8 = 16 \text{ N-sec/m}$$

54. 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.

Ans. (c)

Sol. • Diameter pitch, $P = \frac{\text{Number of teeth}}{\text{diameter}} = \frac{t}{d}$

Circular pitch, $p = \frac{\pi d}{t}$

$\therefore \qquad p = \frac{t}{d} \cdot \frac{\pi d}{t} = \pi$

- Pressure angle is independent of size and constant for all sizes.
- The tangent to base circle is always normal to tooth curve/profile and passes through pitch point.
- There is no limit of speed as such but depend upon strength of gear material.

55. 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

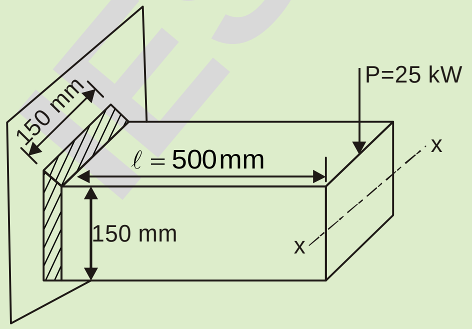
(c) 5 mm (d) 6 mm

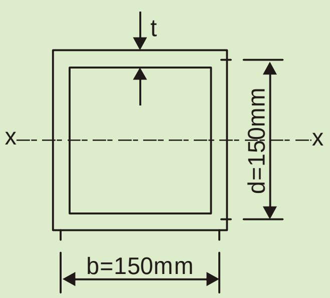
Ans. **(a)**

Sol. Let the throat size of weld is 't'.

Total area of weld,

$$A = 4 \times 150 \times t = 600\ t\ \text{mm}^2$$





$\therefore$ Direct shear stress,

$$\tau_1 = \frac{P}{A} = \frac{25000}{600t}$$

$$= \frac{41.67}{t} \cdot \text{N/mm}^2$$

But the permissible direct shear stress

$$\frac{41.67}{t} \cdot \text{N/mm}^2 = 20\ \text{N/mm}^2$$

$$\therefore \qquad t = \frac{41.67}{20} = 2.1\,\text{mm} \simeq 3\text{mm}$$

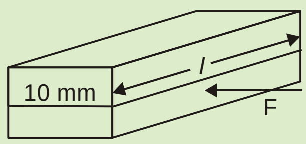
56. A shaft of 50 mm diameter transmits a torque of 800 N-m. The width of the rectangular key used is 10 mm. The allowable shear stress of the material of the key being 40 MPa, the required length of the key would be

(a) 60 mm (b) 70 mm

(c) 80 mm (d) 90 mm

Ans. **(c)**

Sol.



Torque to be transmitted,

$$T = F \cdot \frac{d}{2}$$

$$800 = F \times \frac{50}{2} \times 10^{-3}$$

$\therefore$ Force on key,

$$F = \frac{800}{25}\text{kN} = 32\ \text{kN}$$

$$\tau = \frac{F}{\text{Area}} = \frac{F}{b \cdot \ell}$$

$$40 = \frac{32000}{10 \cdot \ell}$$

$$\therefore \qquad \ell = \frac{3200}{40} = 80\text{mm}$$

57. 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

Ans. (d)

Sol. A governor is said to hunt if the speed of the engine fluctuates continuously above and below the mea speed. This is due to high sensitivity of the governor which changes the fuel supply by a large amount when a small change in the speed of rotation takes place.

58. 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

Ans. (c)

Sol. The size diameter of pin in the rubber bush of driving flange is higher to control the bearing pressure on rubber due to pin. Other reason is fitting of pin inside the flange.

59. The problem of interference in 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

Ans. (b)

Sol. The interference in involute profile teeth is eliminated by

- Increasing centre distance.
- Reducing height of gear teeth i.e. using stub teeth.
- Using composite profile at root of tooth of gear (pinion). This composite profile may be radial or cycloidal.

60. 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

Ans. (c)

Sol. Since bearing modulus 'K' is minimum value of term.

$$K = \frac{ZN}{b} = 1628$$

In actual design, the value of bearing characteristic is three times of bearing modulus.

$\therefore$ Bearing characteristic number,

$= 3K = 3 \times 1628 = 4884$

Directions : Each of the following **twenty (20)** items consists of two statements, one labelled 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

61. **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.

Ans. (c)

Sol. An AGV is a programmable mobile vehicle without human intervention and used for material handling. AS/RS is not a part of CNC machine rather. It is an independent computer controlled material handling system.

62. **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.

Ans. (a)

Sol. In kinematic inversion, the relative motion between links remains same. Hence considering cam as stationary acid follower is rotated about it in opposite direction of cam rotation, displacement diagram of follower in obtained.

63. **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.

Ans. (b)

Sol. A composite material is a combination of two or more chemically distinct and insuluble phases; its properties and structural peformance are superior to those of the constituents acting independently.

Both statements are independently correct.

64. **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.

Ans. (b)

Sol. In epicyclic gear trains, the planetary gear is also called as epicyclic gear. This epicyclic gear moves around central gear causing epicyclic motion.

The arm/handle has bearing at ends which connect the end of arm with centre of gears.

65. **Statement (I) :** Two non-intersecting and non-parallel, i.e., non-coplanar, shafts connected by gears are called skew-beyel 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.

Ans. (d)

Sol. In skew shaft or spiral gears, the contact between gears in point contact. Due to this point contact, these gears are used in light duty applications only.

66. **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.

Ans. (c)

Sol. Differential gears are provided to run the wheels on back axle at different speed during a turn not to run the vehicle on bumpy roads. Vehicle can run without differential on bumpy road.

73. **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 can withstand high temperatures.

Ans. **(c)**

Sol. Ceramic can be used within temperature range from 1000°C to 1600°C, as these are made to withstand high temperatures.

Silicon carbide is not an exception, as all carbides are used for high temperatures.

74. **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.

Ans. **(a)**

Sol. Extrusion is not economical for large billets as large forces are required to overcome the friction between the workpiece and cylinder wall.

75. **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.

Ans. **(c)**

Sol. In closed die drop forcing the excess material added to stock is called flash. Since, this flash cools more rapidly and offers resistance to further flash formation and helps in complete filling of die. However, it does not cushions against hammer blows.

76. **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.

Ans. **(c)**

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

77. **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.

Ans. **(c)**

Sol. In case of low melting point metals used for producing powder through atomization, the size of the particles can be controlled but the shape remains irregular.

78. **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.

Ans. **(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.

79. **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.

Ans. **(c)**

Sol. Moulds for centrifugal casting are made of steel, cast iron, graphite and sand. Sand and plaster moulds are used to make the process faster as multiple mould cavities can be arranged around a central forcing basin.

80. **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.

Ans. **(c)**

Sol. A neutral flame is used to weld stainless steel as it does not react with steel.

81. 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?

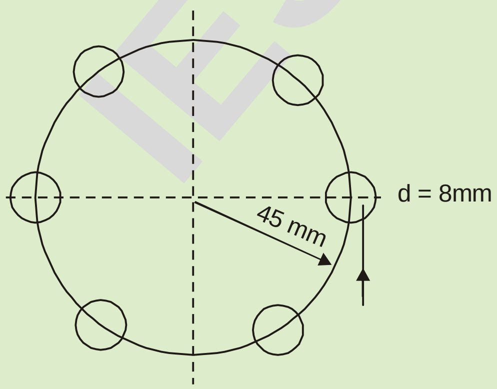
(a) 780 N-m (b) 950 N-m

(c) 1090 N-m (d) 1250 N-m

Ans. **(c)**

Sol. Pitch circle diameter of flange,

D = 90 mm.



The allowable shear stress in bold

τ = 80 MPa = 80N/mm^2

$\therefore$ Force F = $\tau \cdot A$ = $80 \times \frac{\pi}{4} \cdot 8^2 = 4021 \cdot 24\text{N}$

Torque transmitting capacity,

$$= 6\frac{F \cdot D}{2} = 3 \times 4021.24 \times 0.09$$

$$= 1085.7 \text{ N.m}$$

$$\simeq 1090 \text{ N.m}$$

82. 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

Ans. **(b)**

Sol.
- Cost of belt pulley in minimum because pulley are manufactured by casting or welding.
- Spur gear are made by machining which has more cost than belt drive.
- Worm drive is costliest of all because it require special machining and material of wheel.

83. 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 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

Ans. **(d)**

Sol. The power transmitted by a shaft,

$$P = T.\omega = \frac{\pi d^3 \tau}{16} \cdot \omega \qquad \ldots \text{(i)}$$

In second situation the diameter and speed in doubled

$$\therefore \quad P' = \frac{\pi(2d)^3\tau}{16}\cdot 2\omega = \frac{\pi d^3\tau}{16}\omega\cdot 8\times 2$$

$= P \times 16$

$= 100 \times 16$

$= 1600$ KW

84. What shall be the centre cirstance 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

Ans. (c)

Sol. Teeth on pinion, t = 20

Teeth on gear, T = 50

module, m = 6 mm

The centre distance,

$$a = \frac{m(t+T)}{2}$$

$$= \frac{6\times(20+50)}{2}$$

$= 3 \times 70 = 210$ mm

85. 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

Ans. (d)

Sol. Ultimate strength, = 150 MPa

Factor of safely, = 3

$\therefore$ Allowable shear strength

$$S_a = \frac{150}{3} = 50 \text{ MPa}$$

$\therefore$ Power to transmit

$$P = T\cdot\omega = \frac{\pi d^3\tau}{16}\cdot\omega$$

$$25000 = \frac{\pi d^3\times 50}{16}\times\frac{2\pi\times 1500}{60}$$

d = 25.3 mm

86. 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

Ans. (a)

Sol. Thick lubrication is found in both hydrodynamic and hydrostatic lubrication, but metal to metal contact is not allowed.

87. 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 Sommerfeld number is

(a) 5.2×10^6 (b) 10.3×10^6

(c) 15.2×10^6 (d) 20.3×10^6

Ans. (b)

Sol. load on bearing, P = 3672 N

Bearing Diameter, D = 50 mm

length of bearing, l = 0.1 m

Diametral clearance, C = 0.1 mm

Oil Viscosity, Z = 0.06 kg/m.s

The Sommerfeld Number

$$S = \frac{ZN}{P}\left(\frac{d}{c}\right)^2$$

where in pressure in N/mm^2

$$P = \frac{P}{ld} = \frac{3672}{100 \times 50} = 0.7344 \text{ N/m}^2$$

$$S = \frac{0.06 \times 500}{0.7344} \times \left(\frac{50}{0.1}\right)^2 = 10.212 \times 10^6$$

88. 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

Ans. (d)

Sol. The life of ball bearing

$$L = \left(\frac{C}{P}\right)^3 L_{10}$$

where C – dynamic load capacity, and P in equivalent load. Now the dynamic capacity is increased by 1.5 times.

$$\therefore \; L_1 = \left(\frac{1.5C}{P}\right)^3 L_{10} = (1.5)^3 \; L$$

$$= 3.375 \; L$$

$$\simeq 3.4 \; L$$

89. 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

Ans. (c)

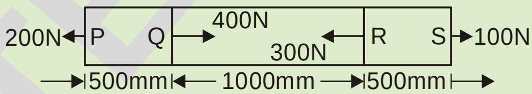
Sol. Speed variation,

N_1 = 120 rpm, N_2 = 150 rpm.

Coefficient of fluctuation of speed,

$$K_1 = \frac{N_2 - N_1}{\bar{N}} = \frac{2(150-120)}{(150+120)} = \frac{60}{270} = 0.222$$

90. 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 :



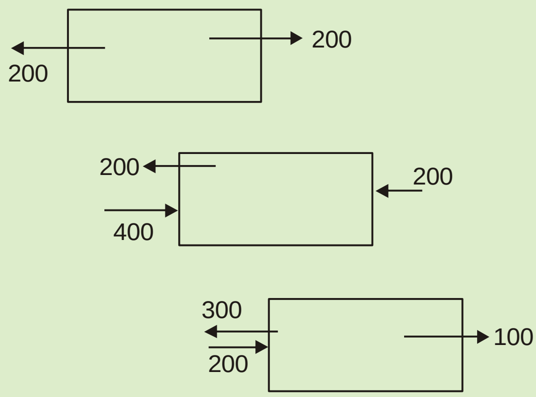
If E_{steel} = 200 GPa, the total change in length of the rod due to loading is

(a) –5 μm (b) –10 μm

(c) –20 μm (d) –25 μm

Ans. (d)

Sol.



$$\Delta = \left(\frac{200 \times 500}{10 \times 2 \times 10^5} + \frac{(-200) \times 1000}{10 \times 2 \times 10^5} + \frac{100 \times 500}{10 \times 2 \times 10^5}\right) \text{mm}$$

$$= \frac{200 \times 500 - 200 \times 1000 + 100 \times 500}{2 \times 10^6}$$

$$= -25 \times 10^{-3} \text{ mm}$$

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

91. 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

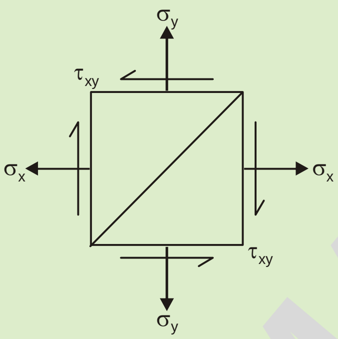
Which of the above is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. (c)

Sol. Maximum shear stress,



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

Normal stress on oblique plane,

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

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

Thus both options are correct.

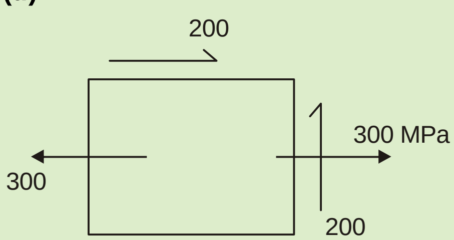
92. A body is subjected to a direct tensile stress of 300 MPa in one plane accompanied by a simple shear stress of 200 MPa. The maximum normal stress on the plane will be

(a) 100 MPa (b) 200 MPa

(c) 300 MPa (d) 400 MPa

Ans. (d)

Sol.



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

$= 400$ MPa

93. 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

Ans. (a)

Sol. Radial compressive stress,

σ_r = –50 N/mm^2

Hoop stress, σ_θ = 75 N/mm^2

Shear stress, $\tau = \left(\frac{\sigma_\theta - \sigma_r}{2}\right)$

$= \frac{75+50}{2}$ = 62.5 N/mm^2

Yield strength, S_y = 350 N/mm^2

Factor of safety, $\frac{S_y}{2\tau} = \frac{350}{2\times 62.5}$ = 2.8

94. The state of stress at a point in a loaded member is σ_x = 400 MPa, σ_y = –400 MPa and τ_{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

Ans. (c)

Sol. σ_x = 400 MPa,

σ_y = –400 MPa,

τ_{xy} = ±300 MPa

$$\sigma_{1,2} = \left(\frac{\sigma_x + \sigma_y}{2}\right) \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{400 - 400}{2} \pm \sqrt{400^2 \pm 300^2}$$

= 0 ± 500

= ± 500 MPa

95. A circular steel rod of 20 cm^3 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, α = 10 × 10^{-6}/°C, the thrust thereby generated on the clamp is

(a) 100 kN (b) 150 kN

(c) 200 kN (d) 250 kN

Ans. (c)

Sol. The thermal strain

$$\frac{\Delta l}{l} = \alpha\Delta t = 10 \times 10^{-6} \times 50 = 5 \times 10^{-4}$$

Stress, $\sigma = \frac{\Delta l}{l} \times E = 5 \times 10^{-4} \times 200 \times 10^4$

= 1000 × 10^5 N/m^2

Force developed, F = $\sigma \cdot A$

= 1000 × 10^5 × 20 × 10^{-4}

= 20 × 10^{8-4}

= 20 × 10^4 N = 200 KN

96. Two steel rods of identical length and material properties are subjected to equal axial loads. The first rod is solid with diameter d an the second is a hollow one with external diameter D and internal 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) $\frac{1}{4}$

Ans. (b)

Sol. Equal length, equal extension under equal load.

$$\text{Strain, } \frac{\Delta l}{l} = \frac{E}{\sigma} = \frac{E \cdot A}{F} \quad \text{... (1)}$$

Hence under these condition, the area must be equal.

$$\therefore \quad \frac{\pi}{4}d^2 = \frac{\pi}{4}\left\{D^2 - \left(\frac{D}{2}\right)^2\right\} = \frac{\pi}{4}\cdot\frac{3}{4}\cdot D^2$$

$$\therefore \quad d = \frac{\sqrt{3}}{2}\cdot D$$

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

97. A steel rod 10 m long is 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 α = 12 × 10^{-6}/°C?

(a) 64 MPa (b) 48 MPa

(c) 32 MPa (d) 16 MPa

Ans. (d)

Sol. Length of rod, l = 10m, α = 12 × 10–6/°C

Free extension of rod,

Dl = lα Dt = 10 × 12 × 10^{-6} × 40 = 4.8 mm

But allowed extension, x = 4mm

$$\therefore \text{ Strain, } = \frac{\Delta l - x}{l} = \frac{48 - 4}{10 \times 10^3} = 8 \times 10^{-5}$$

Stress induced,

σ = Strain × E

$= 8 \times 10^{-5} \times 200 \times 10^{9}$

$= 16 \times 10^{9-3}$

$= 16$ MPa

98. 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

Ans. **(a)**

Sol. $\dfrac{\dot{\varepsilon}_1 - \dot{\varepsilon}_2}{\sigma_1 - \sigma_2} = \dfrac{\dot{\varepsilon}_1 - \dot{\varepsilon}_3}{\sigma_1 - \sigma_3} = \dfrac{\dot{\varepsilon}_2 - \dot{\varepsilon}_3}{\sigma_2 - \sigma_3}$

Levi Mises flow rule, relates principal components of strain rate during plastic loading to principal stresses. Substituting values of $\sigma_1, \sigma_2, \sigma_3$

$$\Rightarrow \frac{\dot{\varepsilon}_1 - \dot{\varepsilon}_2}{30-10} = \frac{\dot{\varepsilon}_1 - \dot{\varepsilon}_3}{30-5} = \frac{\dot{\varepsilon}_2 - \dot{\varepsilon}_3}{10-5}$$

$$\Rightarrow \frac{\dot{\varepsilon}_1 - \dot{\varepsilon}_2}{20} = \frac{\dot{\varepsilon}_1 - \dot{\varepsilon}_3}{25} = \frac{\dot{\varepsilon}_2 - \dot{\varepsilon}_3}{5}$$

Checking the values from option (a).

Putting $\dot{\varepsilon}_1 = 15$, $\dot{\varepsilon}_2 = -5$, $\dot{\varepsilon}_3 = -10$

We have

$$\frac{15-(-5)}{20} = \frac{15-(-10)}{25} = \frac{-5+10}{5}$$

$$1 = 1 = 1$$

Thus values of $\dot{\varepsilon}_1, \dot{\varepsilon}_2, \dot{\varepsilon}_3$ taken are correct.

99. 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

Ans. **(d)**

Sol. The independent state of stress will be any two of I, G and μ.

100. 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

Ans. **(a)**

Sol. The miller indices of a material in a plane are proportional to the reciprocal of numerical parameters of the intercepts.

101. 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 in 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

Ans. **(a)**

Sol. Fracture toughness is given as

$K_1C = y \cdot \sigma \cdot \sqrt{\pi a}$

where 2a is the maximum size of internal crack.

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

$$\left(\frac{3.6}{300}\right)^2 \times \frac{1}{\pi} = a$$

$a = 0.0000458$ or $2a = 0.00009171$ m

or 91.7 μm

102. 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

Ans. (d)

Sol. For isostress condition in a composite material

$$E_C = \frac{E_f E_m}{V_f E_m + V_m E_f}$$

$$= \frac{72 \times 3}{0.6 \times 3 + 0.4 \times 72}$$

$$= \frac{216}{1.8 + 28.8} = 7 \text{ GPa}$$

103. 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

Ans. (c)

Sol. Abrasive ceramics should have high wear resistance, high degree of toughness so that they do not shatter during cutting and refractoriness to withstand high temperature during cutting.

104. 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 blank.
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

Ans. (a)

Sol. In petro forge, a fuel air mixture is used to power upper portion of die to forge components at a speed of 150-200 m/s.

105. 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

Ans. (b)

Sol. Main mechanism of material removal in AJM is brittle fracture of material due to mechanical impact of abrasive particles on surface of the material.

106. 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

Ans. (a)

Sol. Aluminium alloy, magnesium alloys, brass are used for manufacturing dies, moulds in investment casting as dies requires high carbon steels due to high hardness.

107. 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

Ans. (b)

Sol. Rat tail casting defect is a long, shallow angular depression on the surface of casting. It is due to 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.

108. 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

Ans. (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.

109. 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

Ans. (c)

Sol. MRR in turning operation is $\pi D_{avg} \times d \times f \times N$.

But $V = f \times N$

$$f = \frac{V}{N} = \frac{175}{360} \text{ mm/rev.}$$

$$MRR = \pi \times \frac{(10+9)}{2} \times 0.5 \times \frac{175}{360} \times 360$$

$$= \pi \times 9.5 \times 0.5 \times 175$$

$$= 2610 \text{ mm}^3\text{/min.}$$

or 2600 mm^3/mm

110. 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

Ans. (c)

Sol. $$\text{Feed/tooth} = \frac{f}{ZN} = \frac{0.5 \times 1000}{10 \times 360} = \frac{5}{36}$$

$$= 0.1389 \text{ mm/tooth}$$

or 0.14 mm/tooth

111. 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

Ans. (a)

Sol. Cutting force $F_c = \dfrac{\text{Power}}{\text{velocity}}$(Net)

$$= \frac{(2500-500)}{30/60} = \frac{2000}{0.5}$$

= 4000 N

$$\text{Torque} = \frac{\text{Power}}{2\pi N} = \frac{2000\times 60}{2\times\pi\times 120}$$

= 160 N-m

112. 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

Ans. (b)

Sol. Cutting speed of shaper is

$$V = \frac{NL(1+m)}{1000}\text{m/min}$$

where N number of double strokes per minute

$$= \frac{32\times 210\times(1+0.667)}{1000}$$

= 11.20 m/min

L is length of stroke m = return time/cutting time

113. 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

Ans. (c)

Sol. N_{max} = 1600 rpm, N_{min} = 100 rpm

headstroke has 9 speeds

Ratio of G.P is a = $\sqrt[k-1]{\dfrac{N_{max}}{N_{min}}}$

where k is number of headstock speeds

$$\text{Ratio} = \sqrt[8]{\frac{1600}{100}} = 1.41$$

114. Surface cracking occurring at low temperatures in hydrostatic extrusion is known as

(a) fluid defect (b) bamboo defect
(c) fishtailing (d) arrowhead fracture

Ans. (b)

Sol. Bamboo defect is surface cracking at low temperature in hydrostatic extrusion. The crafts appear at spaced intervals around the port's periphery resembling a bamboo tree.

115. 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

Ans. (a)

Sol. Flash wear starts from the nose portion of the tool and extends to relief face or clearance face of the tool.

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

N001	G91	G71 M03 S600 EBOB
N002	G00	X 10.00 Y10.00 EOB
N003	G00	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

Ans. **(a)**

Sol. G83 code is primarily used for drilling deep holes.

117. 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 than 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

Ans. **(*)**

118. 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) $\frac{H}{l} = e\frac{VI}{v}$ (b) $\frac{H}{v} = e\frac{VI}{l}$

(c) $H = e\frac{VI}{vl}$ (d) $H = eVI \cdot vl$

Ans. **(a)**

Sol. Governing equation in are welding is

$$\frac{H}{\ell}\text{(Heat input/mm)} = \frac{e \times V \times I}{\text{velocity}}$$

119. 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) $9.2L^3$ (b) $6.24L^3$

(c) $9.12L^3$ (d) $9.86L^3$

Ans. **(a)**

Sol. Volume of outer envelope

$$= \frac{\pi}{4} \times (4L)^2 \times L$$

$$= \frac{\pi}{4} \times 16 \times L^3$$

$$= 4\pi L^3$$

Volume of inaccessible inner envelope

$$= \frac{\pi}{4} \times (2L)^2 \times L = \pi L^3$$

Thus, work envelope of cylendrical robot is

$$= 4\pi L^3 - \pi L^3 = 3\pi L^3 = 9.424\, L^3$$

120. 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.

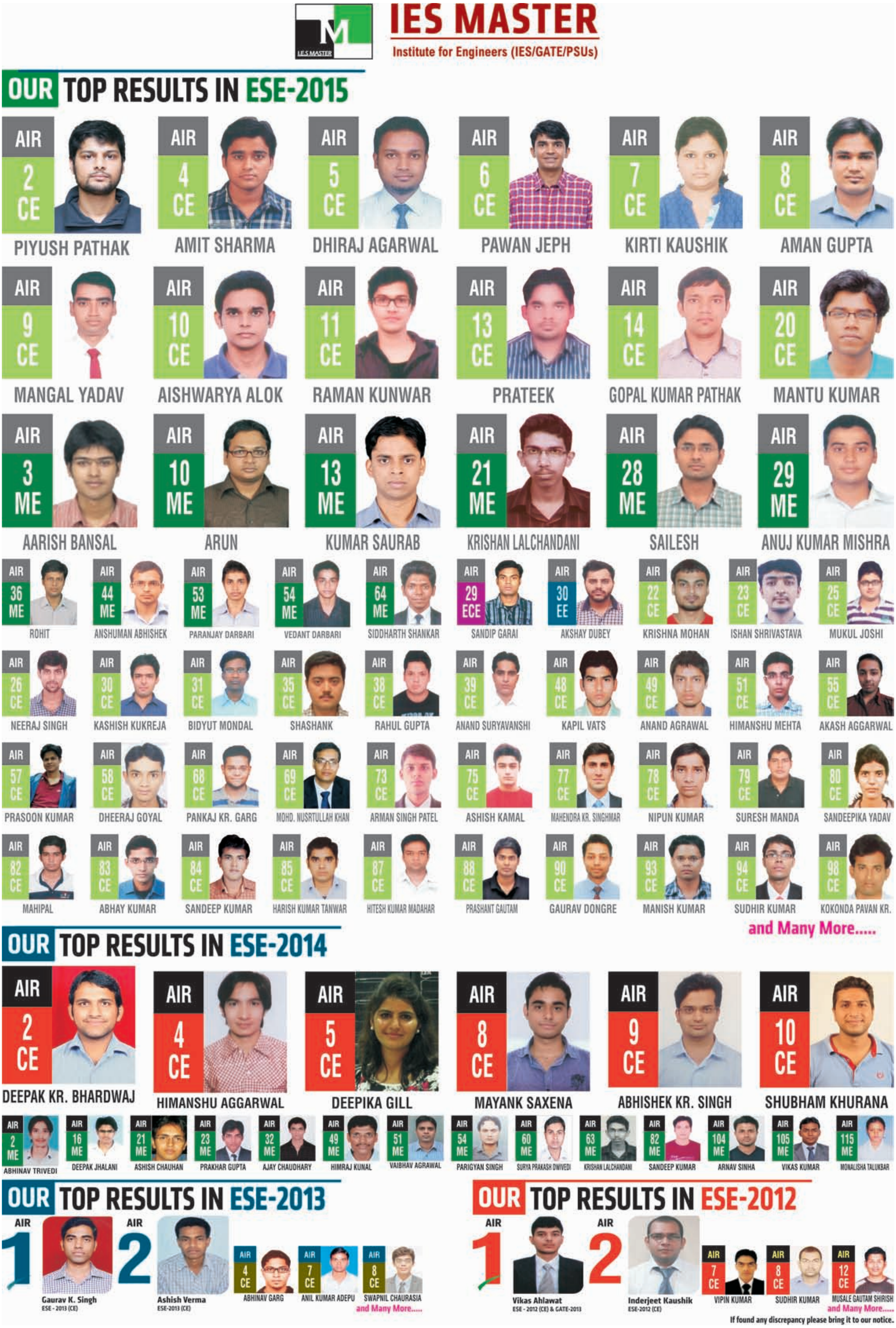
Which of the above statements are correct?

(a) 1 and 2 only (b) 1 and 3 only

(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(c)**

Sol. Forgings have high strength and reduced ductility due to work hardening. Forging have high impact and fatigue strength as well.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AIR 7 CE KIRTI KAUSHIK
AIR 8 CE AMAN GUPTA
AIR 9 CE MANGAL YADAV
AIR 10 CE AISHWARYA ALOK
AIR 11 CE RAMAN KUNWAR
AIR 13 CE PRATEEK
AIR 14 CE GOPAL KUMAR PATHAK
AIR 20 CE MANTU KUMAR
AIR 3 ME AARISH BANSAL
AIR 10 ME ARUN
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AIR 26 CE NEERAJ SINGH
AIR 30 CE KASHISH KUKREJA
AIR 31 CE BIDYUT MONDAL
AIR 35 CE SHASHANK
AIR 38 CE RAHUL GUPTA
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AIR 51 CE HIMANSHU MEHTA
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AIR 82 CE MAHIPAL
AIR 83 CE ABHAY KUMAR
AIR 84 CE SANDEEP KUMAR
AIR 85 CE HARISH KUMAR TANWAR
AIR 87 CE HITESH KUMAR MADAHAR
AIR 88 CE PRASHANT GAUTAM
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AIR 12 CE MUSALE GAUTAM SHIRISH
and Many More.....
If found any discrepancy please bring it to our notice.