IES MASTER

Institute for Engineers (IES/GATE/PSUs)

UPPSC 2020

Assistant Engineer Prelims Exam

Mechanical Engineering

Paper-I

Detailed Solution (SET-A)

Exam Date - 13th December Time - 09:00 AM - 11:30 AM

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SET - A

1. 'चीनांशुक' शब्द का अर्थ है
   (a) तंतु (b) रेणु
   (c) रेशम (d) चीनी मिट्टी

Ans. (c)

2. निम्नलिखित में से तद्भव शब्द है
   (a) वानर (b) तेल
   (c) पीत (d) घोटक

Ans. (b)

3. अनेकार्थक शब्द 'सारंग' का निम्नलिखित में से एक अर्थ नहीं है
   (a) भौंरा (b) कामदेव
   (c) तलवार (d) ज्योतिषी

Ans. (d)

4. 'अंदर-अंदर कड़ाही में गुड़ पगना' - इस मुहावरे का सही अर्थ है
   (a) ज्ञान होना
   (b) गुप्त मंत्रणा होना
   (c) स्वसीमित होना
   (d) किसी काम न आना

Ans. (b)

5. निम्नलिखित में से शुद्ध वर्तनी का शब्द है
   (a) अनाधिकार (b) रचइता
   (c) सहस्र (d) संग्रहीत

Ans. (c)

6. समास-योजना की दृष्टि से इनमें से एक अशुद्ध युग्म है
   (a) सतसई - द्विगु समास
   (b) तुलसीकृत - तत्पुरुष समास
   (c) मंदोदरी - बहुव्रीहि समास
   (d) मरणासन्न - अव्ययीभाव समास

Ans. (d)

7. अलग होने के अर्थ में 'से' कारक-चिन्ह का प्रयोग होता है
   (a) अपादान कारक में
   (b) करण कारक में
   (c) करण कारक तथा अपादान कारक दोनों में
   (d) सम्बन्ध कारक में

Ans. (a)

8. 'पवन' शब्द का सन्धि-विच्छेद है
   (a) पौ+अन (b) पो+अन
   (c) प+अवन (d) प+वन

Ans. (b)

9. इनमें से शुद्ध वर्तनी का रूप है
   (a) निरझरणी (b) निरझरिणी
   (c) निर्झरिणी (d) निर्झरणी

Ans. (c)

10. निम्नलिखित में से एक शब्द में उपसर्ग का प्रयोग नही हुआ है, वह शब्द है
   (a) सहज (b) अनुभव
   (c) संचार (d) नयन

Ans. (a)

11. इनमें से 'अनघ' का विलोम शब्द है

(a) निरघ (b) अघी
(c) कृती (d) सनघ

Ans. (b)

12. इनमें से 'पक्षी' शब्द का पर्यायवाची नहीं है

(a) पिशुन (b) विहंग
(c) शकुनि (d) द्विज

Ans. (a)

13. नीचे दिये गये वाक्यांश और उसके लिए प्रयुक्त होने वाले शब्द का एक युग्म गलत है, वह है

(a) उत्तरधिकार में प्राप्त सम्पत्ति–धरोहर
(b) जिसे प्रमाण द्वारा सिद्ध न किया जा सके–अप्रमेय
(c) सीमा का अनुचित रूप से किया गया उल्लंघन–अतिक्रमण
(d) पूरब और उत्तर (दिशा) के बीच का कोना–ईशान

Ans. (a)

14. निम्नलिखित में से 'महीसुर' शब्द का अर्थ है

(a) पृथ्वी का रक्षक (b) महिषासुर
(c) राक्षस (d) ब्राह्मण

Ans. (a)

15. निम्नलिखित में से तत्सम शब्द है

(a) विवाह (b) ईख
(c) खीर (d) गिद्ध

Ans. (a)

16. 'ने+अन'='नयन' में सन्धि है

(a) यण सन्धि (b) गुण सन्धि
(c) अयादि सन्धि (d) वृद्धि सन्धि

Ans. (c)

17. निम्नलिखित में से शुद्ध वर्तनी का शब्द है

(a) उज्ज्वल (b) उज्जवल
(c) उजवल (d) उज्वल

Ans. (a)

18. 'बुद्धिहीन' शब्द व्याकरण की दृष्टि से इनमें से किस संवर्ग में है?

(a) संज्ञा (b) सर्वनाम
(c) विशेषण (d) क्रिया

Ans. (c)

19. इनमें से दन्त्य ध्वनियाँ है

(a) च, छ, ज, झ
(b) प, फ, ब, भ
(c) त, थ, द, ध
(d) ट, ठ, ड, ढ

Ans. (c)

20. इनमें से एक वाक्य शुद्ध है, वह है

(a) मेरा प्राण संकट में है।
(b) सोमवार को रेलवे के कई कर्मचारी गिरफ्तार हुए।
(c) अपराधी को मृत्युदंड की सजा दी गयी है।
(d) महादेवी वर्मा छायावाद की प्रसिद्ध कवयित्री है।

Ans. (d)

21. इनमें से व्यंजन सन्धि आधारित शब्द है

(a) अन्वेषण (b) उद्धार
(c) लघूर्मि (d) पुरोहित

Ans. (b)

22. 'चौराहा' शब्द में समास है

(a) तत्पुरुष (b) बहुव्रीहि

(c) अव्ययीभाव (d) द्विगु

Ans. (d)

23. 'निवृत्ति' शब्द का विलोम है

(a) सद्वृत्ति (b) सुवृत्ति

(c) प्रवृत्ति (d) कुवृत्ति

Ans. (c)

24. निम्नलिखित में से 'शारदा' का पर्यायवाची शब्द है

(a) कमला (b) कौमुदी

(c) वारुणी (d) गिरा

Ans. (d)

25. 'मृत्यु के इच्छुक' – इस वाक्यांश के लिए एक शब्द है

(a) मुमुक्षा (b) मुमूर्षु

(c) मुमूर्षा (d) मुमुक्षु

Ans. (b)

26. A circular solid rod of diameter 'd' welded to a rigid flat plate by a circular fillet weld of throat thickness 't' is subjected to a twisting moment 'T'. The maximum shear stress induced in the weld is

(a) $\frac{T}{\pi t d^2}$ (b) $\frac{2T}{\pi t d^2}$

(c) $\frac{4T}{\pi t d^2}$ (d) $\frac{8T}{\pi t d^2}$

Ans. (b)

Sol. The maximum shear stress induced in weld is

$$= \frac{2.83T}{\pi d^2 t} \simeq \frac{2T}{\pi d^2 t}$$

27. The notch sensitivity q is expressed in terms of fatigue stress concentration factor K_f and theoretical stress concentration factor K_t as

(a) $\frac{K_f+1}{K_t+1}$ (b) $\frac{K_f-1}{K_t-1}$

(c) $\frac{K_t+1}{K_f+1}$ (d) $\frac{K_t-1}{K_f-1}$

Ans. (b)

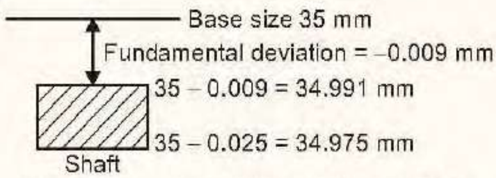
28. A shaft has dimension $\varphi 35(-0.009 \text{ to } -0.025)$. The respective values of fundamental deviation and tolerance are

(a) –0.025, ±0.008 (b) –0.025, 0.016

(c) –0.009, ±0.008 (d) –0.009, 0.016

Ans. (c)

Sol.



Fundamental deviation, FD = – 0.009 mm

Mean value,

$$\bar{x} = \frac{34.991+34.975}{2} = 34.983 \text{ mm}$$

Tolerance = 34.983 ± 0.008 mm

29. A thin walled spherical shell is subjected to an internal pressure. If the radius of the shell is increased by 1% and the thickness is reduced by 1% with the internal pressure remaining the same, the % change in circumferential (hoop) stress is

(a) 0 (b) 1

(c) 1.08 (d) 2.02

Ans. (d)

Sol. $\sigma = \frac{Pd}{4t}$

$$\sigma' = \frac{P \times d\left(\frac{100+1}{100}\right)}{4t\left(\frac{100-1}{100}\right)} = \frac{Pd \times 101}{4t \times 99} = 1.0202\sigma$$

$$\% \text{ change} = \frac{\sigma' - \sigma}{\sigma} = \frac{(1.0202-1)\sigma}{\sigma} \times 100$$

= 2.02%

30. If there are n_1 discs on the driving shaft and n_2 discs on the driven shaft in a multi-plate clutch, then the number of pairs of contact surface is

(a) $n_1 + n_2$ (b) $n_1 + n_2 - 1$

(c) $n_1 + n_2 + 1$ (d) $n_1 + n_2 + 2$

Ans. (b)

Sol. In a multiplate clutch numbers of pairs of contact surfaces (n) is equal to $n_1 + n_2 - 1$.

Where n = always whole numbers.

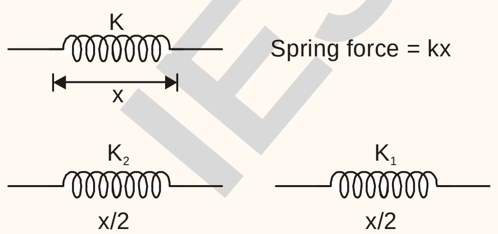
31. When a helical compression spring is cut into halves, the stiffness of the resulting spring will be

(a) One half (b) One fourth

(c) Double (d) Same

Ans. (c)

Sol.



$$\frac{K_2 \times x}{2} = Kx \qquad K_1 \times \frac{x}{2} = Kx$$

$$K_2 = 2K \qquad K_1 = 2K$$

32. Chromium as an alloying element in alloy steel is used principally to

(a) Improve harden ability

(b) Improve mechanical properties at low temperature

(c) Improve mechanical properties at elevated temperature

(d) Improve the corrosion and oxidation resistance

Ans. (d)

33. The compositions of some of the alloy steels are as under

1. 18W4Cr1V 2. $12M_01W4Cr1V$

3. $5M_06W4Cr2V$ 4. 18W8Cr1V

The composition of commonly used high speed steels would include

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

(c) 1 and 4 (d) 1 and 3

Ans. (d)

34. The materials which show direction dependent properties are called

(a) Homogeneous materials

(b) Viscoelastic materials

(c) Isotropic materials

(d) Anisotropic materials

Ans. (d)

Sol. Anisotropic materials also known as triclinic materials are directional dependent medium that are made up of unsymmetrical crystalline structure.

35. Atomic radius of Face Centred Cubic (FCC) crystal is

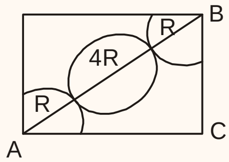
a = lattice parameter

(a) $\frac{a\sqrt{2}}{4}$ (b) $\frac{a\sqrt{3}}{2}$

(c) $\frac{a\sqrt{3}}{4}$ (d) $\frac{a\sqrt{2}}{3}$

Ans. (a)

Sol.



$AB^2 = AC^2 + BC^2$

$(4R)^2 = a^2 + a^2$

$$R^2 = \frac{2a^2}{16}$$

$$\boxed{R = \frac{\sqrt{2}\,a}{4}}$$

36. Which of the following phase of steel is NOT present in iron-carbon phase diagram?

(a) Ferrite (b) Cementite

(c) Austenite (d) Martensite

Ans. (d)

Sol. On iron phase diagram ferrite, cementite and austenite all are found. Martensite is found on S curve.

37. The machine tool guide ways are usually hardened by

(a) Induction hardening

(b) Flame hardening

(c) Vacuum hardening

(d) Martempering

Ans. (d)

38. Twin boundaries are which type of crystal defect?

(a) Line defect

(b) Point defect

(c) Surface defect

(d) None of the above

Ans. (c)

Sol. Twin boundaries are 2D effect i.e. surface defect in crystal.

39. The function of interpolator in a CNC machine controller is to

(a) Control spindle speed

(b) Control feed rate of axes

(c) Control tool rapid speed

(d) Perform miscellaneous (M) function

Ans. (b)

40. During calculation of material removal rate in electro-discharge machining, supply voltage was used 60V in place of the actual supply voltage 40V. Condition for maximum power delivery to the discharge circuit is satisfied. The ratio of actual to calculated material removal rate will be

(a) $\frac{3}{2}$ (b) $\frac{4}{9}$

(c) $\frac{9}{4}$ (d) $\frac{2}{3}$

Ans. (c)

Sol. MMR $\propto$ Power supply

or, MMR $\propto \frac{V^2}{R}$

where V = voltage, R = resistance

$$\frac{MRR_1}{MRR_2} = \frac{V_1^2}{V_2^2} = \frac{(60)^2}{(40)^2} = \frac{36}{16} = \frac{9}{4}$$

41. Straing polarity in arc welding is obtained with

(a) Alternating current electrode with electrode being positive

(b) Direct current electrode with electrode being positive

(c) Direct current electrode with electrode being negative

(d) Alternating current electrode with electrode being negative

Ans. (c)

Sol. Direct current straight polarity occurs when electrode is made negative and base plates are made positive.

42. A good machinability rating would indicate

(a) Long tool life, high power requirement and less machining time

(b) Long tool life, low power requirement and a good surface finish

(c) Short tool life and a good surface finish

(d) Long tool life, high power requirement and a good surface finish

Ans. (b)

43. Find the blanking force required to punch 10 mm diameter holes in a steel sheet of 3 mm thickness. Given shear strength of material = 400 MPa, penetration = 40% and shear provided on the punch = 2 mm.

(a) 22.6 kN (b) 37.7 kN

(c) 61.6 kN (d) 94.3 kN

Ans. (a)

Sol. $F = \frac{\pi dtr(tp)}{s}$

s = 400 MPa, P = penetration = $\frac{40}{100}$ = 0.4

t = thickness = 3 mm = 3×10^{-3} m

d = 10 mm = 10×10^{-3}

So, by above formula

$F = \frac{45238}{2} = 22619 \text{ N} = 22.61 \text{ kN}$

44. If the speed of machining combined cemented carbide and steel tool is halved, then the tool life changes by (assume Taylor's exponent = 0.25 for single point turning operation)

(a) 2 times (b) 4 times

(c) 8 times (d) 16 times

Ans. (d)

Sol.

$$VT^n = C$$

$$VT^{0.25} = C$$

$$V_1T_1^{0.25} = V_2T_2^{0.25}$$

$$V_1T_1^{0.25} = \frac{V_1}{2}T_2^{0.25}$$

$$T_2 = 16T_1$$

45. In which of the following welding process flux is fed separately?

(a) Electric arc welding

(b) Plasma arc welding

(c) Tungsten inert gas arc welding

(d) Submerged arc welding

Ans. (d)

46. Which of the following operation does NOT use a jig?

(a) Tapping (b) Reaming

(c) Turning (d) Drilling

Ans. (c)

Sol. Fixtures are used in turning operation.

47. In machining operation if path of generatrix and directrix are circular and straight line respectively, the surface obtained will be

(a) Cylindrical

(b) Helical

(c) Plain

(d) Surface of revolution

Ans. (a)

48. Critical path method is good for

(a) Small projects only

(b) Large projects only

(c) Both small and large projects equally

(d) Neither small nor large projects

Ans. **(b)**

Sol. CPM also known as critical path analysis, the critical path method widely used technique for analyzing and managing task sequences in large projects.

For small projects manager are able to memorize and coordinate all of the variables and utilities.

49. Term "Value" in value engineering refers to

(a) Total cost of the product

(b) Selling price of the product

(c) Utility of the product

(d) Manufacturing cost of the product

Ans. **(c)**

Sol. Value engineering refers to the systematic method of improving the value of a product that a project produces. Value engineering encourages using alternative methods and materials that are less expensive and do not lower the functionality of the system.

50. Classifying items in A, B and C categories for selective control in inventory management is done by arranging items in the decreasing order of

(a) Total inventory cost

(b) Item value

(c) Annual usage value

(d) Item demand

Ans. **(c)**

Sol. Annual usage value in ABC inventory system, products are categorised in the categories A, B and C by arranging items in decreasing order.

51. An industry produces 300 spark plugs in one shift of 8 hours. If standard time per piece is 1.5 minute, the productivity would be

(a) $\frac{3}{4}$ (b) $\frac{5}{8}$

(c) $\frac{7}{16}$ (d) $\frac{15}{16}$

Ans. **(d)**

Sol. Total time for 300 spank plug = 300 × 1.5

So, in 1 minute = 300 × 1.5

In 8 hours = $\frac{450}{60 \times 80} = \frac{15}{16}$

52. In sampling inspection the maximum % defective that can be treated satisfactory as a process average is

(a) Rejectable Quality Level (RQL)

(b) Acceptable Quality Level (AQL)

(c) Average Outgoing Quality Limit (AOQL)

(d) Lot Tolerance Percent Defective (LTPD)

Ans. **(b)**

Sol. Acceptance quality level is the maximum percent defective that is considered satisfactory as a process average by the producer and consumer.

53. A technology for application of mechanical, electronics and computer based systems to control and operate the systems is called

(a) PLC

(b) Sequential controller

(c) Microprocessor based systems

(d) Automation

Ans. **(d)**

Sol. Automation is the technology by which a process or procedure is performed with minimum human assistance. It uses various control system for operating the system.

54. Which of the following devices produces incremental motion through equal pulses?

(a) AC servo motor (b) DC servo motor
(c) Stepper motor (d) Series motor

Ans. (c)

55. The degree of freedom of a SCARA robot are

(a) Six (b) Five
(c) Four (d) Three

Ans. (c)

56. Hall sensor is used to measure the following

(a) Position of shaft
(b) Angular velocity
(c) Strength of magnetic field
(d) All the above

Ans. (c)

Sol. Hall effect is applied in magnetic field and Hall sensor is used to measure strength of magnetic field. The output of Hall sensor is directly proportional to the magnetic field strength.

57. Work done by non-conservative forces on a particle is equal to

(a) Change in kinetic energy
(b) Change in mechanical energy
(c) Change in potential energy
(d) Change in internal energy

Ans. (b)

Sol. Work done by non-conservative force changes the mechanical energy of system.

$$W_{nc} = \Delta KE + \Delta PE$$

58. If a distributed force system on a beam is replaced by its statically equivalent force system, which of the following is same for both the beams?

(a) Support reactions
(b) Shear force diagram
(c) Bending moment diagram
(d) Maximum bending moment

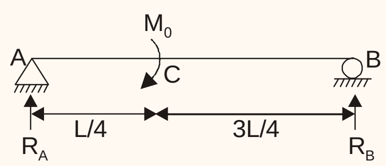
Ans. (a)

59. A simply supported beam of span L is subjected to a moment M_0 at a distance of $\frac{L}{4}$ from the left end. Magnitude of the maximum bending moment in the beam is

(a) M_0 (b) $\frac{M_0}{2}$
(c) $\frac{M_0}{4}$ (d) $\frac{3M_0}{4}$

Ans. (d)

Sol.

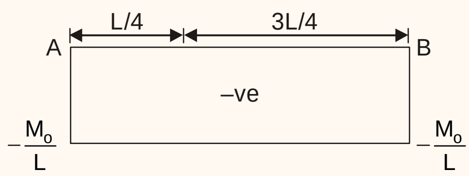


$$\sum M_A = 0$$

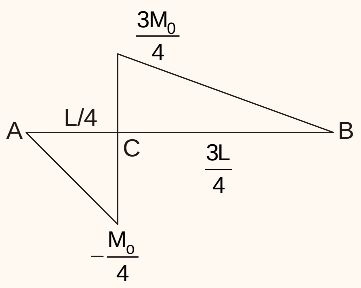
$$\Rightarrow M_0 - R_B \times L = 0$$

$$\Rightarrow R_B = \frac{M_0}{L} \ \& \ R_A = -\frac{M_0}{L}$$

SFD

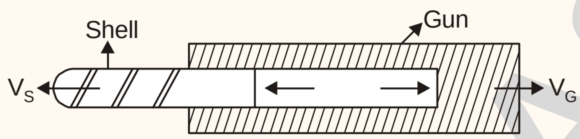


BMD



Maximum bending moment = $\frac{3M_0}{4}$

60. A gun of mass 3000 kg fires horizontally a shell of mass 50 kg with a velocity of 300 m/s. What is the velocity with which the gun will recoil?



(a) –5 m/s (b) 10 m/s

(c) 50 m/s (d) 30 m/s

Ans. **(a)**

Sol. m_g = 3000 kg, m_b = 50 kg, v_g = ?,

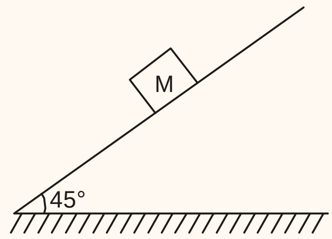
V_b = 300 m/s

Linear momentum will be conserved i.e initial momentum = Final momentum

$$0 = m_g V_g + m_b V_b$$

$$V_g = -\frac{50 \times 300}{3000} = -5 \text{ m/s}$$

61. A body of mass (M) 10 kg is initially stationary on a 45° inclined plane as shown in figure below. The coefficient of dynamic friction between the body and inclined plane is 0.5. The body slides down the inclined plane and attains a velocity of 20 m/s. The distance travelled (in meter) by the body along the inclined plane is

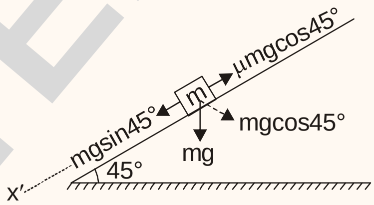


(a) 5.78 m (b) 57.8 m

(c) 34.6 m (d) 3.46 m

Ans. **(b)**

Sol.



$$a_x' = \frac{mg\sin 45° - \mu mg\cos 45°}{m}$$

$$a_x' = g \times \frac{1}{\sqrt{2}} - 0.5 \times g \times \frac{1}{\sqrt{2}}$$

$$a_x' = 0.5 \times 9.81 \times \frac{1}{\sqrt{2}} = 3.468 \text{ m/s}^2$$

$\Rightarrow$ $V^2 = u^2 + 2as$

$\Rightarrow$ $(20)^2 = 0 + 2 \times 3.468 \times S$

$$\boxed{S = 57.67 \text{m}}$$

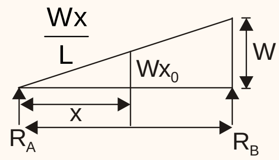
62. A simply supported beam of span l caries a uniformly variable load of intensity $w_0 x$ over its entire span. Maximum beinding moment in the beam is

(a) $\frac{w_0 l^3}{27}$ (b) $\frac{w_0 l^3 \sqrt{3}}{27}$

(c) $\frac{w_0 l^3 \sqrt{2}}{9}$ (d) $\frac{w_0 l^3}{9}$

Ans. **(b)**

Sol.



$$R_B \times L = \frac{W \times L}{2} \times \frac{2L}{3}$$

$$R_B = \frac{WL}{3}$$

$$R_A = \frac{WL}{6}$$

$$M_x = R_A \times x - \text{Load along A} \times \frac{x}{3}$$

$$= \frac{WL}{6}x - \frac{Wx^2}{2L} \times \frac{x}{3}$$

$$= \frac{WL}{6}x - \frac{Wx^3}{6L}$$

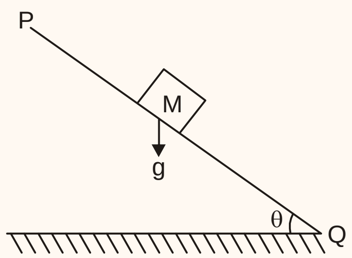
Maximum bending moment occurs at

$$x = \frac{L}{\sqrt{3}}$$

$$BM = \frac{WL}{6} \times \frac{L}{\sqrt{3}} - \frac{W}{6L}\left(\frac{L}{\sqrt{3}}\right)^3$$

$$= \frac{WL^3}{9\sqrt{3}} = \frac{WL^3}{27}\sqrt{3}$$

63. A block of mass M is released from point P on a rough inclined plane with angle of inclination θ as shown in figure below. The coefficient of friction is μ. If $\mu < \tan\theta$, then the time taken by the block to reach point Q on the inclined plane, where PQ = S is



(a) $\sqrt{\dfrac{2S}{g\cos\theta(\tan\theta-\mu)}}$

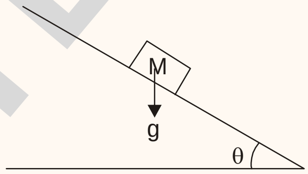
(b) $\sqrt{\dfrac{2S}{g\cos\theta(\tan\theta+\mu)}}$

(c) $\sqrt{\dfrac{2S}{g\sin\theta(\tan\theta-\mu)}}$

(d) $\sqrt{\dfrac{2S}{g\sin\theta(\tan\theta+\mu)}}$

Ans. (a)

Sol.



$$ma = mg\sin\theta - \mu mg\cos\theta$$

$$a = g\sin\theta - \mu g\cos\theta$$

$$S = ut + \frac{1}{2}at^2$$

As $u = 0$

$$t = \sqrt{\frac{2S}{a}}$$

So, $$t = \sqrt{\frac{2S}{(g\sin\theta - \mu g\cos\theta)}}$$

$$t = \sqrt{\frac{2S}{g\cos\theta(\tan\theta-\mu)}}$$

64. Moment of inertia of a thin spherical shell of mass M and radius R, about its diameter is

(a) MR^2

(b) $\frac{MR^2}{2}$

(c) $\frac{2}{5}MR^2$

(d) $\frac{2}{3}MR^2$

Ans. **(c)**

Sol.

$$I = \frac{8}{15}\left[\frac{M}{\frac{4}{3}IR^3}\right]IR^5 = \frac{2}{5}MR^2$$

Note:

$$dI = \frac{1}{2}y^2 dm$$

$$= \frac{1}{2}\times y^2 \times \rho dv$$

$$= \frac{1}{2}y^2 \times \rho\pi y^2 dz$$

$$I = \frac{8}{15}\rho\pi R^5$$

$$\rho = \frac{M}{V} = \frac{M}{\frac{4}{3}\pi R^3}$$

65. Which one of the following can completely balance several masses revolving in different planes on a shaft?

(a) A single mass in different planes

(b) A single mass in one of the planes of the revolving masses

(c) Two masses in any two planes

(d) Two equal masses in any two planes

Ans. **(c)**

66. Linear acceleration of slider in slider crank mechanism may be expressed as: (r = radius of the crank, l = length of the connecting rod and $n = \frac{l}{r}$)

(a) $\omega^2 r[\cos\theta + \sin 2\theta / n]$

(b) $\omega^2 r[\cos\theta + \cos 2\theta / n]$

(c) $\omega^2 r[\sin\theta + \sin 2\theta / n]$

(d) $\omega r[\cos\theta + \cos 2\theta / n]$

Ans. **(b)**

Sol. Linear acceleration of slider in slider crank mechanism = $\omega^2 r\left[\cos\theta + \frac{\cos 2\theta}{n}\right]$

67. The effect of the mass of spring can be considered for calculating natural frequency of a spring mass system by adding 'n' times the mass of spring to the main mass. The value of 'n' is

(a) $\frac{1}{2}$

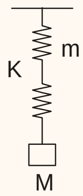
(b) $\frac{1}{3}$

(c) $\frac{1}{4}$

(d) $\frac{2}{3}$

Ans. **(b)**

Sol.



$$T = 2\pi\left[\frac{M + m/3}{K}\right]$$

In the above n = 1/3 as per the question.

68. In a radial cam translating follower mechanism, the offset is provided to

(a) Decrease the pressure angle during descent of the follower

(b) Decrease the pressure angle during ascent of the follower

(c) Increase the pressure angle during ascent of the follower

(d) Avoid any obstruction due to other machine parts

Ans. **(b)**

Sol. Due to offset of the follower, stroke length of the follower is less as compared to follower with zero offset. Less stroke length means for

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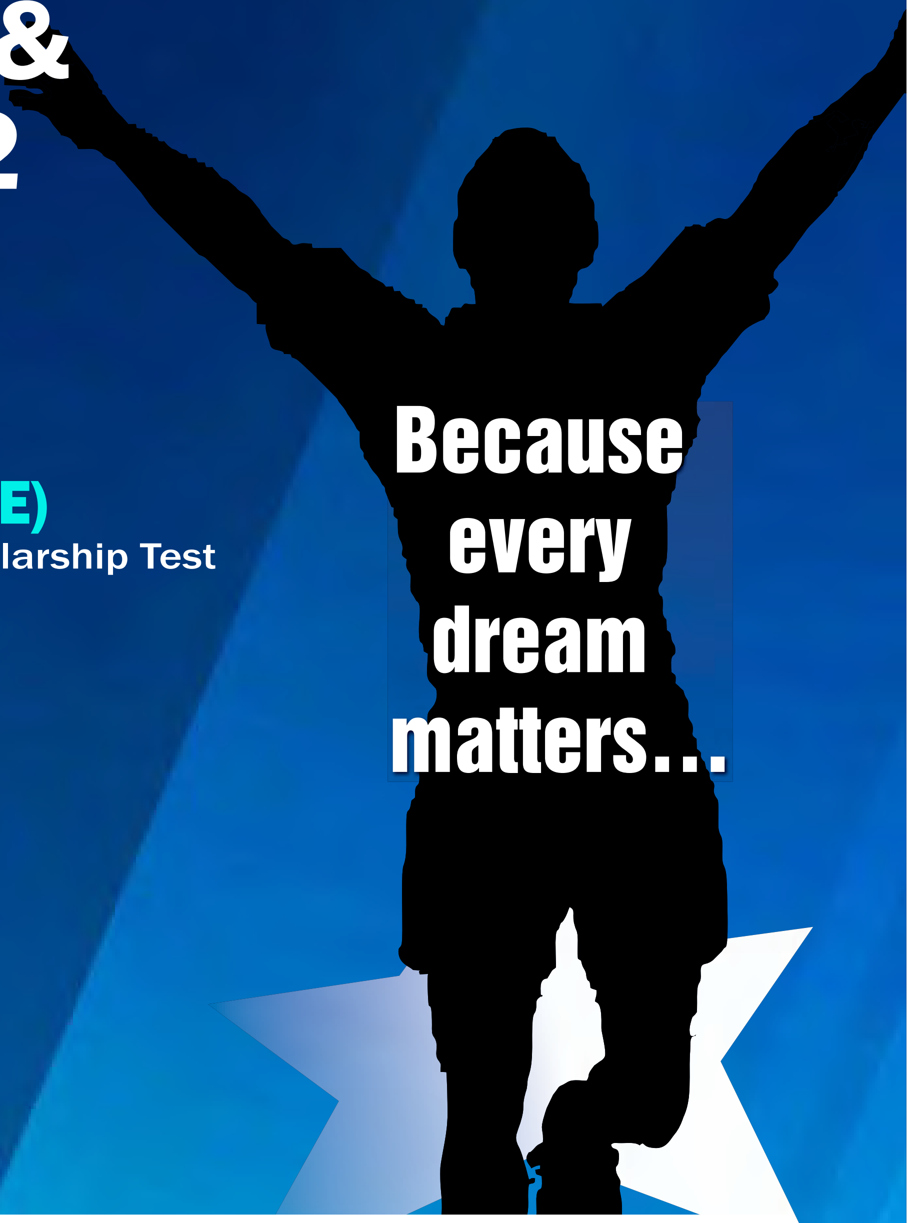

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follower movement will be less because of this spring will also compressed less which decrease the pressure angle during ascent of the follower.

69. 20° full depth involute profile 19 tooth pinion and 37 teeth gear are in mesh. If the module is 5 mm, then the centre distance between the gear pair is

(a) 140 mm (b) 150 mm

(c) 280 mm (d) 300 mm

Ans. **(a)**

Sol. Radius of pitch circle radius of pinion

$$r_p = mt/2 = \frac{5\times 19}{2}$$

Pitch circle radius of gear

$$r_G = \frac{mT}{2} = \frac{5\times 37}{2}$$

So, the centre distance in b/w these.

$$r_P + r_G = \frac{5\times 19}{2} + \frac{5\times 37}{2}$$

$$= \frac{5(19+37)}{2} = 5 \times 28 = 140$$

70. Initial tension in the belt of a belt drive is T_o. At the point of maximum power transmission, the belt speed is given by (where m is mass of unit length of belt)

(a) $\sqrt{\frac{T_o}{m}}$ (b) $\sqrt{\frac{3T_o}{m}}$

(c) $\frac{T_o}{3m}$ (d) $\sqrt{\frac{T_o}{3m}}$

Ans. **(d)**

Sol. When a belt is first fitted to a pair of pulleys, an initial tension T_a is given to the belt when the system is stationary. When transmitting power, the tension on the tight side increases to T_1 and that on slack side decreases to T_2. If it is assumed that the material of the belt is perfectly elastic, i.e the strain in the belt is proportional to stress in it and the total length of the belt remains unchanged, the tension on the tight side will increase by the same amount as the tension on the slack side decreases. If this change in the tension is δT, then tension on tight side, $T_1 = T_0 + \delta T$

Tension on slack side, $T_2 = T_0 - \delta T$

$\therefore$ $T_0 = \frac{T_1+T_2}{2}$ = mean of the tight and the slack side tensions.

Initial tension with centrifugal tension

Total tension on tight side = $T_1 + T_c$

Total tension on slack side = $T_2 + T_c$

$$T_0 = \frac{(T_1+T_c)+(T_2+T_c)}{2}$$

$$= \frac{T_1+T_2}{2} + T_c$$

or $T_1 + T_2 = 2(T_0 - T_c)$

Let $\frac{T_1}{T_2} = e^{\mu\theta} = k$

Therefore, $kT_2 + T_2 = 2(T_0 - T_c)$

$$T_2 = \frac{2(T_0 - T_c)}{k+1}$$

and $$T_1 = \frac{2k(T_0 - T_c)}{k+1}$$

$$T_1 - T_2 = \frac{2k(T_0 - T_c)}{k+1} - \frac{2(T_0 - T_c)}{k+1}$$

$$= \frac{2(k-1)(T_0 - T_c)}{k+1}$$

Power transmitted, $P = (T_1 - T_2)$

$$v = \frac{2(k-1)(T_0 - T_c)}{k+1} v$$

$$= \frac{2(k-1)(T_0 - mv^2)}{k+1}v$$

$$= \frac{2(k-1)(T_0 v - mv^3)}{k+1}$$

To find the condition for maximum power transmission, differentiating this expression with respect to v and equating the same to zero, i.e $\frac{dP}{dv} = T_0 - 3mv^2 = 0$,

$T_0 = 3\,mv^2$, $v = \sqrt{\frac{T_0}{3m}}$

71. A cantilever beam, 2m in length is subjected to a uniformly distributed load of 10 kN/m. If E = 200 GPa and I = 1000 cm^4, the strain energy stored in the beam will be

(a) 7 Nm (b) 12 Nm

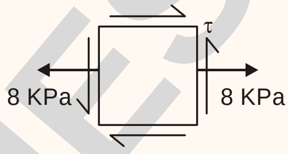
(c) 8 Nm (d) 40 Nm

Ans. **(a)**

Sol.

$$U = \left|\frac{5x^3}{3E}\right|_0^2 = \frac{40}{3EI} = 7$$

72. For the plane stress state shown below if the largest stress is 10 KPa, find the magnitude of unknown shear stress (τ).

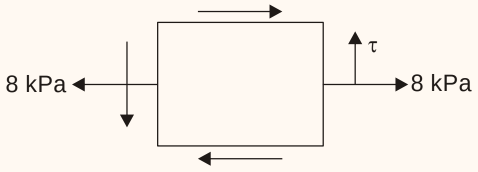


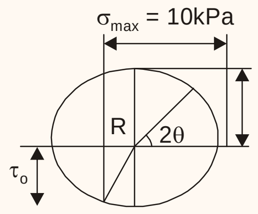
(a) 3.47 KPa (b) 4.47 KPa

(c) 5.47 KPa (d) 6.47 KPa

Ans. **(b)**

Sol.





$$\sigma_{av} = \frac{1}{2}(\sigma_x + \sigma_y)$$

$$= \frac{1}{2}(8+0) = 4 \text{ kPa}$$

$$\sigma_{max} = \sigma_{av} + R$$

R = 10 – 4 = 6 kPa raidus of mohr's circle

$$\cos 2\theta = \frac{4}{6} = \frac{2}{3}$$

$$2\theta = 48.18$$

$$\theta = 24.09$$

$$\tau_0 = R \sin 2\theta = 6 \sin 48.18 \simeq 4.47 \text{ kPa}$$

73. Consider a two dimensional state of stress for an element

where, σ_x = 200 MPa

σ_y = –100 MPa

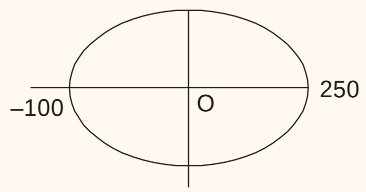
The coordinates of the centre of Mohr's circle are

(a) (0, 0) (b) (100, 200)

(c) (200, 100) (d) (50, 0)

Ans. **(d)**

Sol.



$$\text{Co-ordinate} = \left(\frac{200-100}{2}, 0\right)$$

$$= (50,\ 0)$$

74. What is the maximum torque transmitted by a hollow shaft of external radius 'R', internal radius 'r' and maximum allowable shear stress τ?

(a) $\frac{\pi}{16}(R^3 - r^3)\tau$ (b) $\frac{\pi}{2R}(R^4 - r^4)\tau$

(c) $\frac{\pi}{8R}(R^4 - r^4)\tau$ (d) $\frac{\pi}{32}(R^4 - r^4)\tau$

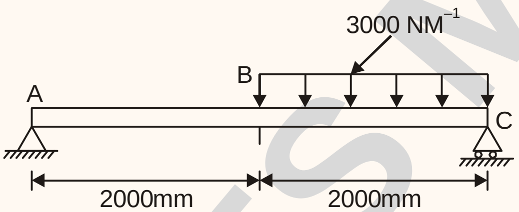
Ans. **(b)**

Sol.

$$T = \tau \times \frac{\pi}{16}\left[\frac{(2R)^4 - (2r)^4}{2R}\right]$$

$$= \tau \times \frac{\pi}{2R}(R^4 - r^4)$$

75. A massless beam has a loading pattern as shown in the figure. The maximum bending moment occurs at



(a) Location B

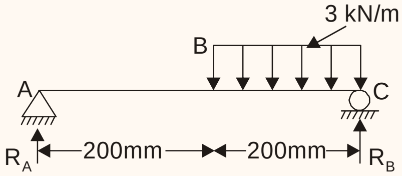
(b) 2675 mm to the right of A

(c) 2500 mm to the right of A

(d) 3225 mm to the right of A

Ans. **(c)**

Sol.



$$\sum M_A = 0 \Rightarrow 3 \times 2(2+1) - R_B \times 4 = 0$$

$$R_B = 4.5 \text{ kN}$$

$$R_A + R_B = 3 \times 2 = 6 \text{ kN}$$

$$\Rightarrow \quad R_A = 1.5 \text{ kN}$$

Maximum bending moment will occur at the location of zero shear force. Let shear force is zero in portion BC, at distance x from A

$$V_x = 1.5 - 3 \times (x-2) = 0$$

$$\Rightarrow \quad 3x = 7.5$$

$$x = 2.5 \text{ m} = 2500 \text{ mm}$$

76. Internal and external radii of a thick cylinder are a and b. It is subjected to an internal pressure of p_i. The radial stress at a radius r in the cylinder is

(a) $\frac{a^2 p_i}{(b^2 - a^2)}\left(1 - \frac{a^2}{r^2}\right)$

(b) $\frac{a^2 p_i}{(b^2 - a^2)}\left(1 - \frac{b^2}{r^2}\right)$

(c) $\frac{b^2 p_i}{(b^2 - a^2)}\left(1 - \frac{a^2}{r^2}\right)$

(d) $\frac{b^2 p_i}{(b^2 - a^2)}\left(1 - \frac{b^2}{r^2}\right)$

Ans. **(b)**

Sol. If internal pressure = P_i and external pressure is zero.

Circumfreritial hoop stress is

$$= \frac{P_i r_i^2}{r_0^2 - r_i^2}\left[\frac{r_0^2}{r^2} + 1\right]$$

r_i = inside radius

r_0 = outside radius

Radial stress is given by

$$\sigma_r = \frac{P_i r_i^2}{(r_0^2 - r_i^2)}\left(1 - \frac{r_0^2}{r}\right) = \frac{P_i \times a^2}{b^2 - a^2}\left(1 - \frac{b^2}{r^2}\right)$$

77. A shaft is subjected to a bending moment M = 0.75 kNm and a twisting moment T = 1 kNm. The magnitude of equivalent bending moment in shaft is

(a) 1.25 kNm (b) 1.125 kNm
(c) 1.0 kNm (d) 0.75 kNm

Ans. **(c)**

Sol. Equivalent bending moment

$$= \frac{1}{2}\left[M + \sqrt{M^2 + T^2}\right]$$

$$= \frac{1}{2}\left[0.75 + \sqrt{(0.75)^2 + 1^2}\right]$$

= 1 kNm

78. If the size of a standard specimen for a fatigue testing machine is increased, the endurance limit for the material will

(a) Have same value as that of standard specimen
(b) Increase
(c) Decrease
(d) None of the above

Ans. **(c)**

Sol. As more surface area per unit volume will face the fatigue behaviour so endurance limit $\downarrow$.

79. If the load on a ball bearing is halved, its life

(a) Remains unchanged
(b) Increases two times
(c) Increases four times
(d) Increases eight times

Ans. **(d)**

Sol. $LP^3 = C$

$$L_1P_1^3 = L_2\left(\frac{P_1}{2}\right)^3$$

$$L_2 = 8L_1$$

80. The deflection of a close coiled helical spring with 20 active turns under a load of 1000N is 10 mm. The spring is divided into two pieces each of 10 active turns and placed in parallel under the same load. The deflection of this system is

(a) 20 mm (b) 10 mm
(c) 5 mm (d) 2.5 mm

Ans. **(d)**

Sol. Deflection $\propto \frac{1}{\text{stiffness}}$

$$\delta \propto \frac{8D^3n}{Gd^4} \propto n \text{ (Number of turns)}$$

As number of turns comes to half of its original value, so deflection reduced to half and by using it in the parallel system, stiffness increased to double from its previous system, so deflection further gets halved.

Hence, deflection of the new system,

$$\delta' = \frac{\delta}{4} = 2.5 \text{ mm}$$

81. Find the dynamic load carrying capacity of a roller bearing if the shaft rotates at 1500 rpm, radial load acting on the bearing is 6 kN and the expected life for 90% life of the bearing of 8100 hours.

(a) 6 kN (b) 54 kN
(c) 54000 kN (d) 60000 kN

Ans. **(b)**

Sol. $$L = \left(\frac{c}{w}\right)^K$$

K = 3 for ball bearing

L_H = 8100

$$L = \left(\frac{C}{6\times10^3}\right)3\times10^6$$

$L = 60\ NL_H$

$$60 \times 1500 \times 8100 = \left(\frac{C}{6\times10^3}\right)3\times10^6$$

$$C = 54 \times 10^3 = 54 \text{ kN}$$

82. If 'w' is the load on a cylindrical journal of diameter (d) and length (l), then bearing pressure is

(a) $\frac{2w}{\pi d^2}$ (b) $\frac{4w}{\pi d^2 l}$

(c) $\frac{w}{\pi d l}$ (d) $\frac{w}{d l}$

Ans. **(d)**

Sol. Bearing pressure $= \frac{W}{\ell d}$

83. δ-iron occurs in the temperature range of

(a) Between 400°C to 600°C

(b) Between 600°C to 900°C

(c) Between 900°C to 1400°C

(d) Between 1400°C to 1539°C

Ans. **(d)**

Sol. 'δ' iron occures in b/w 1400 to 1539 °C

γ-iron 910 to 768 °C and 768 to 910°C it is autenitic phase.

84. Tensile test performed on Universal Testing Machine (UTM) actually measures

(a) True Stress and True Strain

(b) Young's Modulus and Poisson's ratio

(c) Engineering Stress and Engineering Strain

(d) Load and Elongation

Ans. **(d)**

Sol. UTM'S are generally equipped with an automatic stress strain plotting system which gives engineering stress and strain for a given amount of load and gauge length of piece by the use of this mathematical results can be calculated as load and elongation.

85. The process which does NOT improve the fatigue strength of a material is

(a) Shot peening of the surface

(b) Electroplating of the surface

(c) Polishing of the surface

(d) Cold rolling of the surface

Ans. **(b)**

Sol. Electroplating introduces tensile residual stresses in the surface. These tensile residual stresses enhance the magnitude of overall tensile stresses acting on the component during service, hence ↓ the fatigue strength.

86. Which of the following are the advantages of polymer composite materials?

1. Higher Specific Strength
2. Higher Specific Modulus
3. Higher Corrosion Resistance
4. Higher Residual Stresses

(a) 1, 2, 3 (b) 1, 2, 4

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

Ans. **(a)**

Sol. Advantages: 1. Higher specific strength

2. Higher specific modulus
3. Higher corrosion resistance
4. Low residual stresses.

87. Stainless steels are highly corrosion resistance due to the presence of

(a) Chromium (b) Manganese

(c) Molybdenum (d) Nickel

Ans. **(a)**

Sol. Chromium formed cromiumdioxide (Cr_2O_3) on stainless steel body which is corrosion resistent.

88. Packing efficiency of Body Centered Cubic (BCC) crystal is

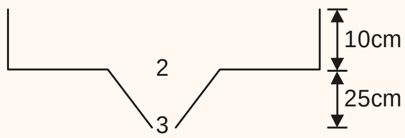
(a) 0.68 (b) 0.74

(c) 0.50 (d) 0.65

Ans. (a)

Sol. In BCC 68% of total volume is occupied by atoms.

89. For the sprue shown below what should be the area at point 3 in order to avoid aspiration effect? Given area at point 2 = 125 cm^2.

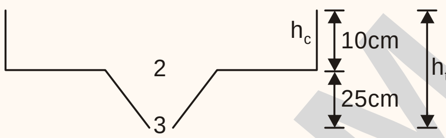


(a) 79.05 cm^2 (b) 105.84 cm^2

(c) 66.81 cm^2 (d) 96.82 cm^2

Ans. (c)

Sol.



$$R = \frac{A_3}{A_2} = \frac{\sqrt{h_c}}{\sqrt{h_t}}$$

$$= \frac{A_3}{125} = \sqrt{\frac{10}{35}}$$

$$A_3 = 125 \times \sqrt{\frac{10}{35}}$$

$$= 125 \times 0.5345 = 66.81 \text{ cm}^2$$

90. Spring back during the sheet metal operation is caused because of the

(a) Release of the stored energy during the elastic and plastic deformation

(b) Release of the stored energy during the plastic deformation

(c) Release of the stored energy during the elastic deformation

(d) Excess energy that was utilized during the forming process

Ans. (c)

Sol. Springback is the amount of elastic deformation a material has to go through before it becomes permanently deformed or formed. It is the amount of elastic tolerance, which is to some extent present in every material.

91. In computer aided part programming by Automatically Program Tool (APT), "COOL NT/ON" is a

(a) Geometry Statement

(b) Motion Statement

(c) Post Processor Statement

(d) Set up Statement

Ans. (c)

Sol. COOLNT/ON: coolant fluid to be turned on

FEDRAT/4.5 (Feedrate for the foot in inch per min)

SPINDL/850 (Spinde rotation speed)

Above all are post processor statement.

92. An orthogonal cutting operation is being carried out under the following conditions :

Cutting speed = 2 m/sec

Depth of cut = 0.5 mm

Chip thickness = 0.6 mm.

What is the chip velocity?

(a) 2 m/sec (b) 2.4 m/sec

(c) 1 m/sec (d) 1.66 m/sec

Ans. (d)

Sol. $$\frac{V}{\cos(\theta - \alpha)} = \frac{V_c}{\sin\theta}$$

$$V_c = V \times \frac{0.5}{0.6}$$

$$= 2 \times \frac{0.5}{0.6} = 1.66$$

93. Low helix angle drills are used for drilling holes in

(a) Plastics (b) Copper

(c) Cast steel (d) Carbon steel

Ans. **(c)**

Sol. Low helix angle preferred for drilling a hole in hard and brittle material as helix angle $(\downarrow)$ rake of cutting edge $\downarrow$. Hence cutting edge becomes stronger.

94. In Ultrasonic Machining (USM) process the material removal rate will be higher for materials with

(a) Higher ductility

(b) Higher fracture strain

(c) Lower toughness

(d) Higher toughness

Ans. **(c)**

Sol. In USM, brittle fracture is responsible for removing material, so toughness of job piece should be low.

95. Which of the following represents the type of fit for a hole and shaft pair? Given that hole $= 50^{+0.04}_{+0.00}$ mm and shaft $= 50^{+0.060}_{+0.041}$ mm

(a) Clearance fit (b) Loose fit

(c) Transition fit (d) Interference fit

Ans. **(d)**

Sol. Lower limit of shaft = 50.041

Uper limit of hole = 50.04

As upper limit hole < lower limit of shaft

So it is interference fit.

96. For machining ceramics, glasses and plastics, which method is NOT applicable?

(a) LBM (b) AJM

(c) EDM (d) USM

Ans. **(c)**

Sol. EDM: It is used for cutting any material that is electrically conductive. Glasses, ceramics and plastics are non electric conductor.

97. A comparator for its working depends on

(a) Accurately calibrated scale

(b) Comparison with standard such as slip gauges

(c) Optical device

(d) Limit gauges

Ans. **(b)**

Sol. a comparator for its working depends on comparison with standard gauges. Standard gauge such as slip gauges etc.

98. In machining processes, the percentage of total heat generated in shear action is carried away by the chips to the extent of

(a) 10% (b) 25%

(c) 50% (d) 80%

Ans. **(d)**

Sol. In the entire heat generated, 80% of total heat is carried away by the chip. About 10% is transferred to the tool and remaining 10% is retained by the work piece.

99. Group technology brings together and organises

(a) Parts and simulation analysis

(b) Documentation and analysis

(c) Automation and tool production

(d) Common parts, problems and tasks

Ans. **(d)**

Sol. Group technology brings together and organize common parts, problems and tasks.

100. Which of the following layout is used for the manufacturing of large aircrafts?

(a) Product layout

(b) Process layout

(c) Fixed position layout

(d) Combination layout

Ans. **(c)**

Sol. Fixed position layout is used for manufacturing of large aircraft.

101. The leaving basic variable in simplex method is the basic variable that

(a) has the lowest value

(b) has the smallest coefficient in the key row

(c) has the largest coefficient in the key row

(d) goes to zero first, as the entering basic variable is increased

Ans. **(d)**

Sol. The variable which is replaced is called the leaving variable and the variable which is replaces, is known as entering variables. The variables of basic solution that are assumed to be zero are called non basic variables. All the remaining variables are called basic variables.

102. Material handling and plant location is analysed by

(a) Gantt chart (b) Bin chart

(c) Travel chart (d) Emerson chart

Ans. **(c)**

Sol. A travel chart is a simple table that is useful where there are multiple and (possibly irregular) movement b/w places. It is a variation on the checksheet, indicating movement from and to any combination of a given set of solution.

103. In PERT and CPM network the dummy activity

(a) Consumes time

(b) Consume resources

(c) Is used to preserve the logic

(d) Is a real activity

Ans. **(c)**

Sol. A dummy activity is an activity added to a project schedule as a placeholder. A dummy activity is intended to show a path of action in a project activity diagram an is employed when logical relationship b/w two activities can not be linked by showing the use of arrows linking are activity to other.

104. The following measurement are carried out by internal state sensors of the end effector

(a) Position

(b) Position and Velocity

(c) Velocity and Acceleration

(d) Position, Velocity and Acceleration

Ans. **(d)**

Sol. Internal sensors measure the robot's internal state. They are used to measure position velocity and acceleration of robot joint or end effectors.

105. In a microprocessor, RISC stands for

(a) Restructured Instruction Set Computer

(b) Redefined Instruction Set Computer

(c) Reduced Instruction Set Computer

(d) Regional Instruction Set Computer

Ans. **(c)**

Sol. RISC - Reduced instruction set computer is a type of microprocessor architecture that utilize a small, highly optimized set of instruction.

106. Which of the following provides anti-clockwise and clockwise rotation about the vertical axis perpendicular to the arm?

(a) Shoulder swivel (b) Arm sweep
(c) Wrist bend (d) Elbow extension

Ans. **(b)**

Sol. Arm sweep provides anticlockwise and clockwise rotation about the vertical axis perpendicular to arm while elbow extension provides radial movement (in and out) to the manipulator arm.

107. PLC operates on following signals
(a) Digital (b) Impulse
(c) Analog (d) Frequency

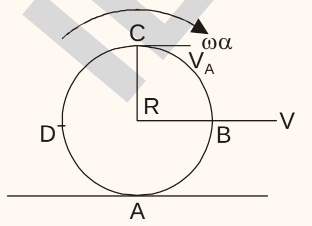
Ans. **(a)**

Sol. The PLC of a computer operates with digital instruction in binary code of '0' and '1'. However field sensors produce on electrical signal in proportion to the effect they are monitoring (analog signal)

108. A disc of radius 30 cm is rolling without slip with angular velocity of 10 rad/s on a horizontal surface. Which of the following statement is NOT true?
(a) Linear velocity of all the points is different
(b) Speed of all the points is different
(c) Acceleration of all the points is different
(d) Linear velocity of all the points touching the horizontal surface is zero

Ans. **(a)**

Sol.



$$V_B = \sqrt{V^2 + (Rw)^2}$$

$$V_C = V + Rw$$

$$V_A = 0$$

i.e $V - Rw = 0$ or, $V = Rw$

So, linear velocity of all points are different $V_A = 0$

109. The ratio of magnitude of linear momentum for two objects having mass 30 kg and 10 kg respectively with equal kinetic energy is

(a) $\sqrt{\frac{1}{3}}$ (b) $(3)^2$

(c) $\sqrt{3}$ (d) $\left(\frac{1}{\sqrt{3}}\right)^2$

Ans. **(c)**

Sol. Kinetic energy $K = \frac{P^2}{2m}$

$$K_1 = \frac{P_1^2}{2m_1}$$

$$K_2 = \frac{P_2^2}{2m_2}$$

According to question,

$$K_1 = K_2$$

$$\frac{P_1^2}{2\times 30} = \frac{P_2^2}{2\times 10}$$

$$\frac{P_1}{P_2} = \frac{\sqrt{3}}{1}$$

110. Condition for stable equilibrium of a conservative force system in terms of potential energy U is

(a) $\delta U = 0$ and $\delta^2 U = 0$

(b) $\delta U = 0$ and $\delta^2 U > 0$

(c) $\delta U = 0$ and $\delta^2 U < 0$

(d) $\delta U > 0$ and $\delta^2 U = 0$

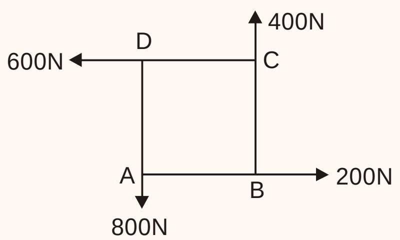
Ans. **(b)**

Sol. For stable equilibrium

$$F = -\frac{du}{dx} = 0$$

i.e $\delta U = 0$ and $\frac{d^2U}{\delta^2 x} > 0$ or positive

111. Four forces having magnitudes of 200N, 400N, 600N and 800N respectively acting along four sides (1m each) of a square ABCD as shown in figure. Determine the magnitude and direction of the resultant force from A along the line AB.



(a) $400\sqrt{3}$N, 3.2m from A

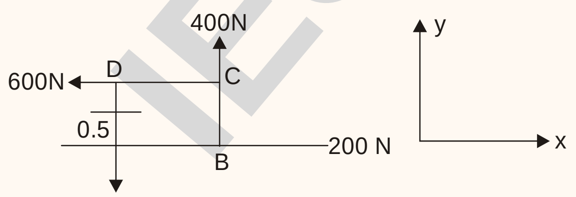
(b) $400\sqrt{2}$N, 2.5m from A

(c) $300\sqrt{2}$N, 2m from A

(d) $300\sqrt{3}$N, 2.5m from A

Ans. **(b)**

Sol.



The resultant force for 4 vectors in xy direction are

600N – 200N = –400N (in –ve x-direction)

800N – 400N = +400N (in +ve y-direction)

So, the net resultant force vector is

$$\vec{R} = \overrightarrow{-400N} + \overrightarrow{400N}$$

θ = 90 angle b/w both vector

So, magnitude is = $2\sqrt{2} \times 200 = 400\sqrt{2}$N

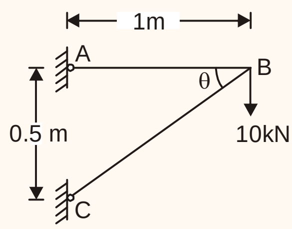
112. A simply supported beam of length l, carries a load $w(x) = w_o(x)$ over the entire span. Maximum bending moment in the beam at x will be

(a) $\frac{l}{3}$ (b) $\frac{l}{\sqrt{3}}$

(c) $\frac{l\sqrt{3}}{2}$ (d) $\frac{l}{\sqrt{2}}$

Ans. **(b)**

113. A two member truss ABC is shown in figure. The axial force (in kN) transmitted in member AB is

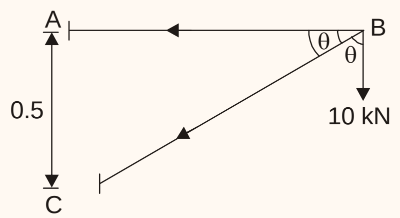


(a) 40 kN (b) 10 kN

(c) 20 kN (d) 30 kN

Ans. **(c)**

Sol.



$$10 = BC\sin\theta$$

$$BC = \frac{10}{\sin\theta}$$

$$AB = BC\cos\theta$$

$$= \frac{10}{\sin\theta} \times \cos\theta$$

$$= 10\cot\theta$$

$$= 10 \times \frac{1}{0.5} = 20$$

114. If the propeller of an aeroplane rotates clockwise when viewed from the rear and the aeroplane takes a right turn, the gyroscopic effect will

(a) Tend to raise the tail and depress the nose

(b) Tend to raise the nose and depress the tail

(c) Tilt the aeroplane about spin axis

(d) Have no effect

Ans. **(a)**

Sol. The engine of an aeroplane rotates clockwise direction when seen from the rear of tail end and aeroplanes takes a turn to right. The effect of gyroscope couple on the aeroplane will be dip the nose and raise the tail.

115. A man is climbing up a ladder which is resting against a vertical wall. When he was exactly halfway up, the ladder started slipping. The path traced by the man is

(a) Parabola (b) Circle

(c) Ellipse (d) Hyperbola

Ans. **(b)**

116. When the primary direct crank of a reciprocating engine positioned at 30° clockwise, the secondary reverse crank for balancing will be at

(a) 30° anticlockwise (b) 60° anticlockwise

(c) 30° clockwise (d) 60° clockwise

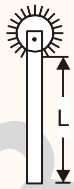
Ans. **(b)**

Sol.

$$\text{Secondary free} = mrw^2 \frac{\cos 2\theta}{n}$$

in opposite direction of primary force.

117. A thin uniform rod of length L and mass M is free to rotate in vertical plane as shown in figure below. The time period of its oscillation in vertical plane is

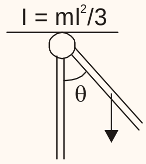


(a) $T = 2\pi\sqrt{\frac{L}{2g}}$ (b) $T = 2\pi\sqrt{\frac{2L}{3g}}$

(c) $T = 2\pi\sqrt{\frac{L}{g}}$ (d) $T = 2\pi\sqrt{\frac{3L}{4g}}$

Ans. **(b)**

Sol.



$$T = 2\pi\sqrt{\frac{I}{mg\ell/2}}$$

$$= 2\pi\sqrt{\frac{m\ell^2}{3 \times mg\ell/2}}$$

$$= 2\pi\sqrt{\frac{2\ell}{3g}}$$

$$I_{rod} = \frac{m\ell^2}{3}$$

118. A 60 kg man is weighed by a balance as 54 kg in a lift which is accelerated downwards. The acceleration of the lift is

(a) 1.26 m/s^2 (b) 1.98 m/s^2

(c) 0.98 m/s^2 (d) 1.76 m/s^2

Ans. **(c)**

Sol.

weight of man = 60 kg = m

$$54 \times 10 = m(g - a) = 60\,(10 - a)$$

$$60a = 600 - 540 = 60$$

$$a = 1 \text{ m/sec} \approx 0.98 \text{ m/sec}$$

as $g = 9.8$

119. Smallest and largest natural frequency of a 'n' degree freedom system are ω_1 and ω_n respectively. Approximate natural frequency estimated by Rayleigh's and Dankerley's methods are ω_r and ω_d respectively. Which of the following statements is true?

(a) $\omega_r < \omega_1$ and $\omega_d < \omega_1$

(b) $\omega_r < \omega_1$ and $\omega_d > \omega_1$

(c) $\omega_r > \omega_1$ and $\omega_d > \omega_1$

(d) $\omega_r > \omega_1$ and $\omega_d < \omega_1$

Ans. **(d)**

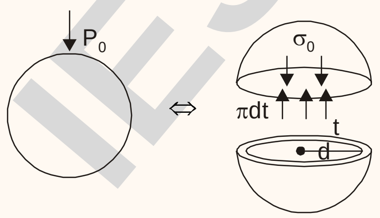
120. A thin spherical shell is subjected to an external pressure p_o. The volumetric strain of the spherical shell is (where, d is the diameter of shell, t is the thickness of the shell, E is Young's modulus of elasticity of shell material, μ is Poisson's ratio of shell material)

(a) $\frac{p_o d}{4tE}(5-4\mu)$ (b) $\frac{3p_o d}{4tE}(1-\mu)$

(c) $\frac{3p_o d}{4tE}(1-2\mu)$ (d) $\frac{-3p_o d}{4tE}(1-\mu)$

Ans. **(c)**

Sol.



Here, $\sigma_x = \sigma_y = \sigma_z = \sigma_0$

$$\epsilon_v = \epsilon_x + \epsilon_y + \epsilon_z = 3\epsilon_0$$

$$= \frac{3\sigma_0(1-2\mu)}{E} \quad \text{...(i)}$$

Hoop stress/ longitudinal stress

Pressure force by fluid ≤ resisting force due to hoop stress

$$P \times \frac{\pi}{4}d^2 \le \sigma_0 \pi dt$$

$$\frac{Pd}{4t} \le \sigma_0$$

$$\sigma_0 = \frac{Pd}{4t}$$

So, from equation (i)

$$\epsilon_v = \frac{Pd}{4tE}(1-2\mu)$$

121. When there is a sudden increase or decrease in shear force diagram between any two points, it indicates that there is

(a) No loading between the two points

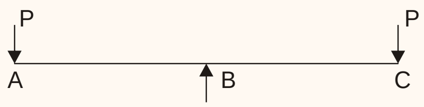
(b) Point load at the two points

(c) Uniformly varying load between the two points

(d) Uniformly distributed load between the two points

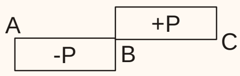
Ans. **(b)**

Sol.



(Beam point load at two point A & C)

S.F



122. Maximum shear stress in a solid shaft of diameter D and length L twisted through an angle θ is τ. A hollow shaft of the same material and length having outside and inside diameters of D and $\frac{D}{2}$ respectively is also twisted through the same angle of twist θ. The value of maximum shear stress in the hollow shaft will be

(a) $\frac{16}{15}\tau$ (b) $\frac{8}{7}\tau$

(c) $\frac{4}{3}\tau$ (d) τ

Ans. **(d)**

Sol.

$$\frac{C\theta}{L} = \frac{\tau}{R} \quad \text{For solid shaft}$$

or, $$\frac{C\theta}{L} = \frac{2\tau}{D}$$

For hollow circular shaft

$$\frac{C'\theta}{L} = \frac{\tau'}{\frac{D}{2}}$$

or, $$\frac{C\theta}{L} = \frac{2\tau'}{D}$$

$$\boxed{\tau' = \tau}$$

Here as material is same so, modulus of rigidity of both shaft will be same i.e $C' = C$

123. A spring used to absorb shocks and vibrations is

(a) Torsion spring (b) Conical spring

(c) Leaf spring (d) Disc spring

Ans. **(c)**

Sol. Leaf springs are made up of a number of leaves of varying length but of equal width and thickness placed in lamination and loaded as beam. Because of such arrangement they are used as shock absorber and vibration absorber. Used in car, automobiles viz truck etc.

124. Two shafts of equal length and similar material in which one is hollow and other is solid are transmitting same level of torque. If the inside diameter is $\frac{2}{3}$ of the outside diameter of the hollow shaft, the ratio of weight of hollow shaft to weight of solid shaft is

(a) 0.642 (b) 0.358

(c) 0.732 (d) 1.444

Ans. **(a)**

Sol.

$$T_{solid} = \frac{\pi}{16}\tau d^3$$

Where D = Dia of solid shaft

$$T_{hollow} = \frac{\pi}{16}\times\tau\left[\frac{D_0^4 - D_i^4}{D_0}\right]$$

$$= \frac{\frac{\pi}{16}\tau\left[D_0^4 - \left(\frac{2}{3}D_0\right)^4\right]}{D_0}$$

$$= \frac{\pi}{16}\times\tau\times\frac{65}{81}D_0^3$$

D_0 = Outside dia of hollow shaft

Considering τ (maximum shear stress is same)

So, $$\frac{\pi}{16}\times\tau\times D^3 = \frac{\pi}{16}\times\tau\times\frac{65}{81}D_0^3$$

$$D^3 = \frac{65}{81}D_0^3;\ D = 0.929D_0$$

w_s = weight of solid shaft = $\rho\times\frac{\pi}{4}\times D^2\times L$ ..(i)

w_h = weight of hollow shaft

$$= \rho\times\frac{\pi}{4}\left[D_0^2 - D_1^2\right]\times L$$

$$= \rho\times\frac{\pi}{4}\times\frac{5}{9}\times D_0^2\times L \quad ...(ii)$$

By equation (i)/(ii)

$$\frac{W_s}{W_h} = \frac{9D^2}{5D_0^2}$$

$$= \frac{9}{5} \times \frac{(0.929D_0)^2}{D_0^2}$$

$$= \frac{1.55}{1}$$

So, $$\frac{W_s}{W_h} = \frac{1}{1.55} \approx 0.642$$

125. For the state of stress of pure shear τ, the strain energy stored per unit volume in the elastic, homogeneous, isotropic material having elastic constants – Young's modulus, E and Poisson's ratio υ will be

(a) $\frac{\tau^2}{E}(1+\upsilon)$ (b) $\frac{\tau^2}{2E}(1+\upsilon)$

(c) $\frac{2\tau^2}{E}(1+\upsilon)$ (d) $\frac{\tau^2}{2E}(2+\upsilon)$

Ans. **(a)**

Sol.

$$\sigma_1 = \tau,\ \sigma_2 = -\tau,\ \sigma_3 = 0$$

$$U = \frac{1}{2E}\left[\tau^2 + (-\tau)^2 - 2\upsilon\tau(-\tau)\right] \times \text{volume}$$

$$= \frac{\tau^2}{2E}(1+\upsilon) \times \text{volume}$$

So, $$\frac{U}{\text{volume}} = \frac{\tau^2}{2E}(1+\upsilon)$$

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