2021

MECHANICAL ENGINEERING

PAPER-I

Time Allowed — 3 Hours *Full Marks — 200*

If the questions attempted are in excess of the prescribed number, only the questions attempted first up to the prescribed number shall be valued and the remaining ones ignored.

Answers may be given either in ***English*** *or in* ***Bengali*** *but all answers must be in one and same language.*

Answer any five *questions.*

1. Choose the correct answer from the options given: 4×10=40

(i) A weight W is supported by two cables as shown in Figure-1. The tension in the left cable T_1 will be minimum when the value of angle θ is

(a) 0°

(b) 30°

(c) 45°

(d) 60°

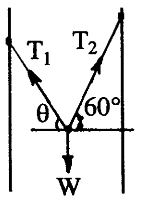


Figure-1

(ii) A system of forces acting on a lamina is shown in Figure-2. The resultant of the force system will meet ABD at

(a) A

(b) B

(c) C

(d) D

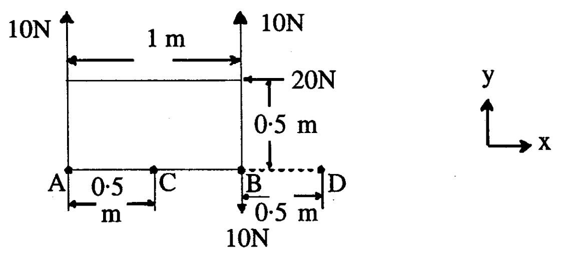


Figure-2

(iii) The state of stress at a point in a loaded member is shown in Figure-3. The magnitude of the maximum shear stress at that point is

(a) 10 MPa

(b) 30 MPa

(c) 50 MPa

(d) 100 MPa

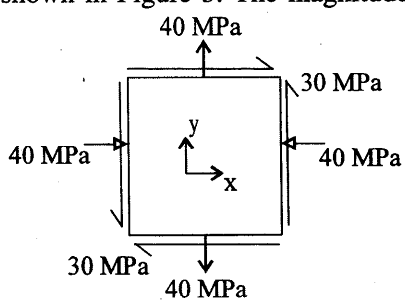


Figure-3

Please Turn Over

(iv) A beam is hinge-supported at its ends and is loaded as shown in Figure-4. The magnitude of shearing force at a section x of the beam is

(a) P

(b) $\frac{PCx}{L^2}$

(c) $\frac{Px}{2L}$

(d) $\frac{PC}{2L}$

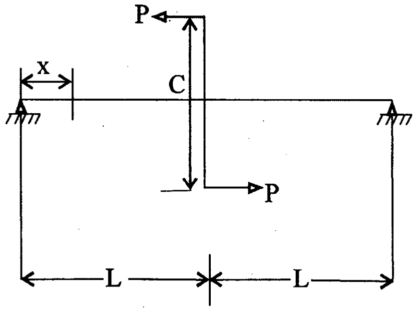


Figure-4

(v) To avoid interference, the maximum length of arc of contact for two externally mating involute gears is

(a) $(r+R)\tan\phi$

(b) $(2r+R)\cot\phi$

(c) $(r+R)\cos\phi$

(d) $(r+R)\sec\phi$

r = pitch circle radius of pinion

R = pitch circle radius of gear

ϕ = pressure angle

(vi) A disc of mass 'm' and radius 'r' is attached to a spring of stiffness 'k'. During its motion the disc rolls on the ground. When released from some stretched position, the centre of the disc will execute simple harmonic motion with a time period of

(a) $2\pi\sqrt{\frac{m}{3k}}$

(b) $2\pi\sqrt{\frac{m}{k}}$

(c) $2\pi\sqrt{\frac{3m}{2k}}$

(d) $2\pi\sqrt{\frac{2m}{k}}$

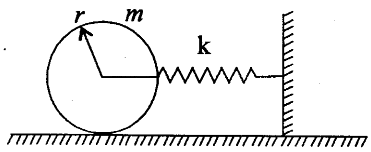


Figure-5

(vii) What is the equivalent stiffness of the system shown in Figure-6?

(a) 24 N/mm

(b) 16 N/mm

(c) 4 N/mm

(d) 8 N/mm

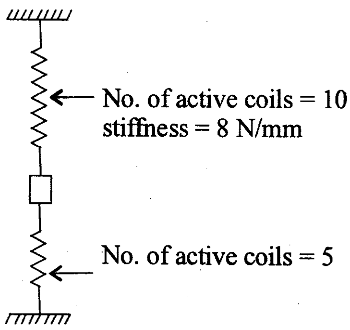


Figure-6

(viii) Match *List-I* with *List-II* and select the correct answer using the codes given below the lists:

List-I	*List-II*
(A) Toughness	(1) Moment area method
(B) Endurance strength	(2) Hardness
(C) Resistance to abrasion	(3) Energy absorbed before fracture in a uni-axial tension test
(D) Deflection in a beam	(4) Fatigue loading

Codes:

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

(ix) Interchangeability can be achieved by

(a) standardization

(b) better process planning

(c) better product planning

(d) machining with precision tools

(x) Conversion of temperature in °F from temperature in °C is given by $\frac{C}{5}=\frac{F-32}{9}$. This is programmed in Fortran as follows:

```
write (*,*) 'Enter temperature in degree Celsius'
read (*,*)C
F = (9/5)*C+32
write (*,*)F
stop
end
```

If temperature in degree Celsius is given as 10, the output F of the program will be

(a) 35·00

(b) 42·00

(c) 50·00

(d) 32·00

2. (a) A vertical cylindrical bar of length 3m and cross-sectional area $6{\cdot}25 \times 10^{-4}$ m^2, is fixed at the top and loaded at the bottom by a force P = 360 kN as shown in Figure-7(a). What is the deflection at the end B of the bar due to this loading? The stress-strain diagram for the material of the bar is shown in Figure-7(b).

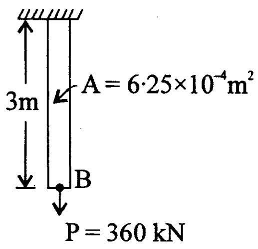


Figure-7(a)

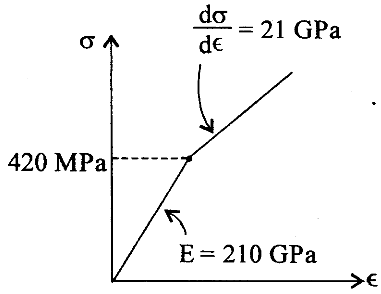
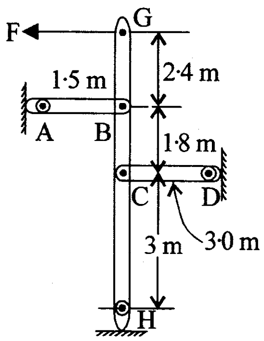


Figure-7(b)

(b) In Figure-8, member GH is taken as perfectly rigid. Members AB and CD are linearly elastic members having moduli of elasticity of 140 GPa and 200 GPa respectively, with equal cross-sectional area of $6{\cdot}25 \times 10^{-4}$ m^2. What are the supporting forces at the pin joint H? Take F = 900 kN. Neglect the weights of the members.



AB = 1·5 m
CD = 3·0 m

Figure-8

20+20=40

3. (a) A beam carrying transverse loads is shown in Figure-9. Draw the shear force and bending moment diagram for the loadings shown. Calculate the maximum normal stress developed in the beam, if the cross-sectional area is rectangular with width = 80 mm and depth = 50 mm.

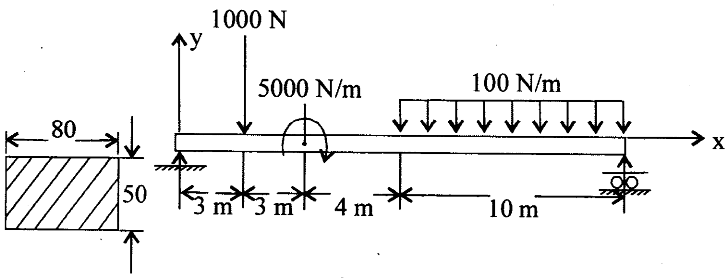


Figure-9

(b) Calculate the maximum deflection of the beam shown in Figure-10. Take modulus of elasticity of the material of the beam = 200 GPa. 20+20=40

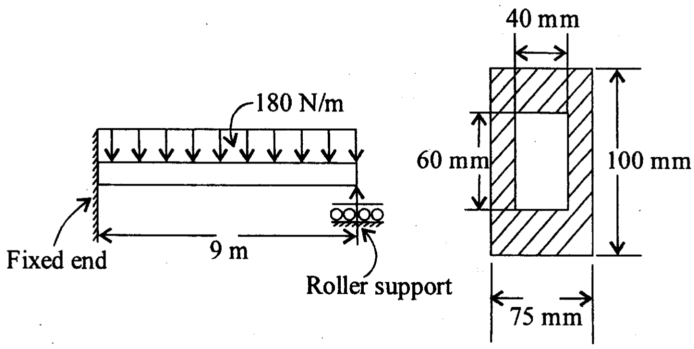


Figure-10

4. (a) The torque exerted on the crankshaft of an engine is given by

$T(N.m) = 10500 + 1620 \sin 2\theta - 1340 \cos 2\theta$,

where θ is the crank angle displacement from the inner dead centre.

Assuming the resistive torque to be constant, determine

(i) the power of the engine when the mean speed is 150 rpm,

(ii) the moment of inertia of the flywheel if the speed variation is not to exceed $\pm$ 0·5% of the mean speed, and

(iii) the angular acceleration of the flywheel when the crank has turned through 30° from the inner dead centre.

(b) Two 20° involute spur gears mesh externally and have a gear ratio equal to 2. The module is 10 mm. The addendum on each wheel is to be made of such a length that the line of contact on each side of the pitch point has half the maximum possible length. Determine (i) the addendum of each gear, (ii) length of the path of contact, (iii) length of the arc of contact, and (iv) contact ratio. Number of teeth on pinion is 20. 20+20=40

5. (a) A shaft is rotating at a uniform angular speed. Four masses of 300 kg, 450 kg, 360 kg and 390 kg respectively are rigidly attached to the shaft. The masses are rotating in the same plane. The corresponding radii of rotation are 200 mm, 150 mm, 250 mm and 300 mm respectively. The angles made by these masses with horizontal are 0°, 45°, 120° and 255° respectively. Calculate

(i) the magnitude of the balancing mass, and

(ii) the position of the balancing mass if its radius of rotation is 200 mm.

(b) What do you mean by 'logarithmic decrement'? Find an expression for logarithmic decrement in terms of damping factor.

(c) In a single-degree damped vibrating system, a suspended mass of 3·75 kg makes 12 oscillations in 7 seconds when disturbed from equilibrium position. The amplitude of vibration reduces to 0·33 times of its initial value after 4 oscillations.
Determine:
(i) Stiffness of the spring
(ii) Logarithmic decrement
(iii) Damping factor
(iv) Damping coefficient 15+10+15=40

6. (a) Distinguish between orthogonal cutting and oblique cutting.
(b) Discuss briefly the continuous chip with built-up edge.
(c) In a machining operation that approximates orthogonal cutting, the cutting tool has a rake angle of 10°. The depth of cut is 0·5 mm and the chip thickness after the cut is 1·125 mm. Calculate the shear plane angle and the shear strain in the operation. If you use any formula then prove it.
(d) For the machining operation mentioned in part (c) above, the cutting force and thrust force are measured as 1559 N and 1271 N respectively. The width of the cutting operation is 3 mm. Calculate the shear strength of the work material and the corresponding friction angle. Also calculate the friction angle for minimum energy consumption rate.
(e) Following are the two observations made in respect of tool life:

Number	Cutting speed (m/min)	Tool life (min)
1	100 m/min	41 min
2	160 m/min	5 min

From the two data above, derive the Taylor's tool life equation. 6+8+8+10+8=40

7. (a) Consider the following problem involving activities from A to J:

Activity	Immediate predecessor(s)	Duration (Months)
A	–	1
B	A	4
C	A	2
D	A	2
E	D	3
F	D	3
G	E	2
H	F, G	1
I	C, H	3
J	B	2

(i) Construct the CPM network.

(ii) Determine the earliest start times.

(iii) Determine the latest finish times.

(iv) Determine the critical path.

(v) Compute total floats and free floats for non-critical activities.

(b) The area of a triangle can be calculated by the formula, area = $\sqrt{s(s-a)(s-b)(s-c)}$, where a, b, c are the side-lengths and $s = \frac{a+b+c}{2}$. The triangle is feasible only when sum of any two side-lengths is greater than the third.

Write a Fortran program to read three side-lengths of a triangle interactively and calculate and print the area. Before calculating the area, the program must check for feasibility of the triangle with the input side-lengths and print appropriate messages. The program must abort itself in case of infeasibility of the triangle. 20+20=40

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