GATE - 2020 - ME

EE1030 : Matrix Theory
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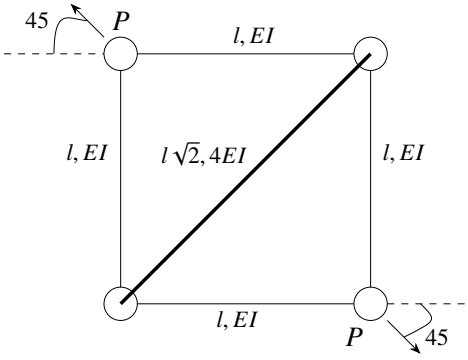
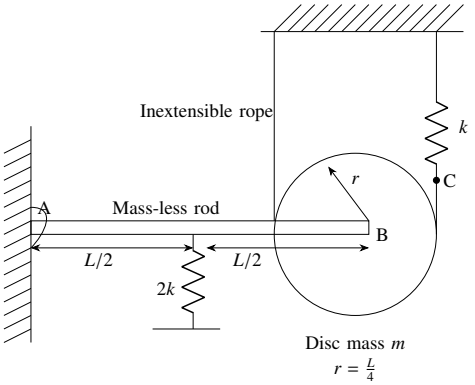
1) The truss shown in the figure has four members of length l and flexural rigidity EI, and one member of length $l\sqrt{2}$ and flexural rigidity $4EI$. The truss is loaded by a pair of forces of magnitude P, as shown in figure.



The smallest value of P, at which any of the truss members will buckle is

a) $\frac{\sqrt{2}\pi^2 EI}{l^2}$
b) $\frac{\pi^2 EI}{l^2}$
c) $\frac{2\pi^2 EI}{l^2}$
d) $\frac{\pi^2 EI}{2l^2}$

2) A rigid mass-less rod of length L is connected to a disc (pulley) of mass m and radius $r = \frac{L}{4}$ through a friction-less revolute joint. The other end of that rod is attached to a wall through a friction-less hinge. A spring of stiffness $2k$ is attached to the rod at its mid-span. An inextensible rope passes over half the disc periphery and is securely tied to a spring of stiffness k at point C as shown in the figure. There is no slip between the rope and the pulley. The system is in static equilibrium in the configuration shown in the figure and the rope is always taut.



Neglecting the influence of gravity, the natural frequency of the system for small amplitude vibration is

a) $\sqrt{\frac{3}{2}}\sqrt{\frac{k}{m}}$
b) $\frac{3}{\sqrt{2}}\sqrt{\frac{k}{m}}$
c) $\sqrt{3}\sqrt{\frac{k}{m}}$
d) $\sqrt{\frac{k}{m}}$

3) A strip of thickness 40 mm is to be rolled to a thickness of 20 mm using a two-high mill having rolls of diameter 200 mm. Coefficient of friction and arc length in mm, respectively are
   a) 0.45 and 38.84
   b) 0.39 and 38.84
   c) 0.39 and 44.72
   d) 0.45 and 44.72

4) For an assembly line, the production rate was 4 pieces per hour and the average processing time was 60 minutes. The WIP inventory was calculated. Now, the production rate is kept the same, and the average processing time is brought down by 30 percent. As a result of this change in the processing time, the WIP inventory.
   a) decreases by 25%
   b) increases by 25%
   c) decreases by 30%
   d) increases by 30%

5) A small metal bead (radius 0.5 mm), initially at 100°C, when placed in a stream of fluid at 20°C, attains a temperature of 28°C in 4.35 seconds. The density and specific heat of the metal are 8500 kg/m^3 and 400 J/kg·K, respectively. If the bead is considered as lumped system, the convective heat transfer coefficient (in W/m^2·K) between the metal bead and the fluid stream is

a) 283.3
b) 299.8
c) 149.9
d) 449.7

6) Consider two exponentially distributed random variables X and Y, both having a mean of 0.50. Let $Z = X + Y$ and r be the correlation coefficient between X and Y. If the variance of Z equals 0, then the value of r is ____ (*round off to* 2 *decimal places*).

7) An analytic function of a complex variable $z = x + iy$ $\left(i = \sqrt{-1}\right)$ is defined as

$$f(z) = x^2 - y^2 + i\psi(x, y),$$

where $\psi(x, y)$ is a real function. The value of the imaginary part of $f(z)$ at $z = (1 + i)$ is ____ (*round off to* 2 *decimal places*).

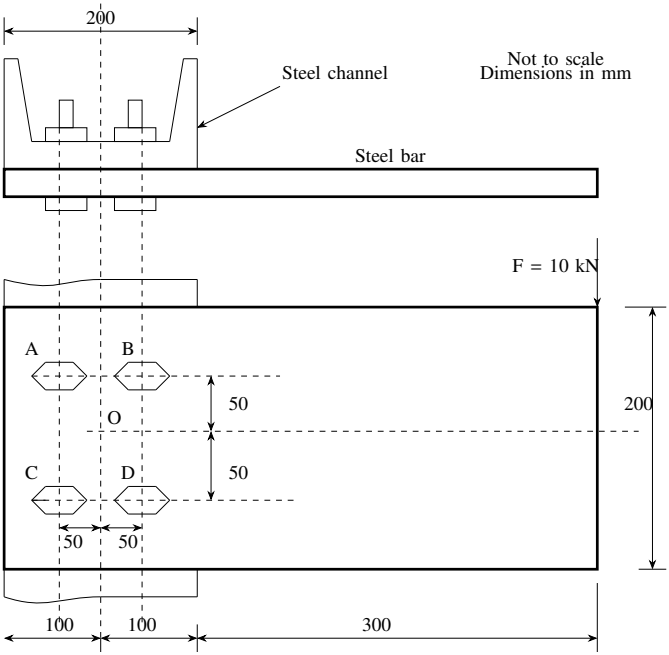
8) In a disc-type axial clutch, the friction contact takes places within an annular region with outer and inner diameters 250 mm and 50 mm, respectively. An axial force F_1 is needed to transmit a torque by a new clutch. However, to transmit the same torque, one needs an axial force F_2 when the clutch wears out. If contact pressure remains uniform during operation of a new clutch while the wear is assumed to be uniform for an old clutch, and the coefficient of friction does not change, then the ratio $\frac{F_1}{F_2}$ is ____ (*round off to* 2 *decimal places*).

9) A cam with translating flat-face follower is desired to have the follower motion

$$y(\theta) = 4\left[2\pi\theta - \theta^2\right],\ 0 \le \theta \le 2\pi$$

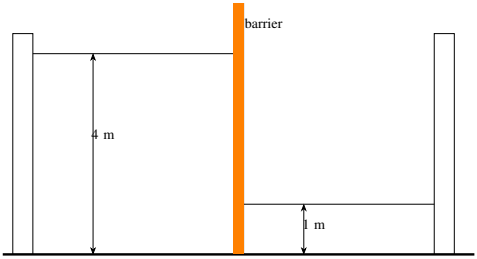
Contact stress considerations dictate that the radius of curvature of the cam profile should not be less than 40 mm anywhere. The minimum permissible base circle radius is ____ mm (*round off to one decimal place*).

10) A rectangular steel bar of length 500 mm, width 100 mm, and thickness 15 mm is cantilevered to a 200 mm steel channel using 4 bolts, as shown.



For an external load of 10 kN applied at the tip of steel bar, the resultant shear load on the bolt at B, is _____ kN (round off to one decimal place).

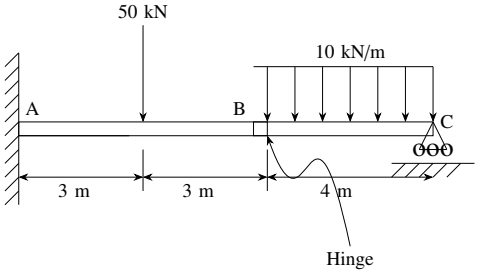
11) The barrier shown between two water tanks of unit width (1 m) into the plane of the screen is modeled as a cantilever.



Taking the density of water as 1000 kg/m^3, and the acceleration due to gravity as 10 m/s^2, the maximum absolute bending moment developed in the cantilever is _____ kN·m (*round off to the nearest integer*).

12) The magnitude of reaction force at joint C of the hinge-beam shown in the figure is _____ kN (*round off to 2 decimal places*).

13) A slot of 25 mm × 25 mm is to be milled in a workpiece of 300 mm length using a side and face milling cutter of diameter 100 mm, width 25 mm and having 20 teeth.



For a depth of cut 5 mm, feed per tooth 0.1 mm, cutting speed 35 m/min and approach and over travel distance of 5 mm each, the time required for milling the slot is _____ minutes (*round off to one decimal place*).