Ref. No.: PRn/Pe/T/113(old)/2019

B.E. PRINTING ENGINEERING EXAMINATION, 2019
(1st Year, 1st Semester, Old)
ENGINEERING MECHANICS

Time: 3 (Three) hours **Full Marks: 100**

Attempt any 5 questions out of 7

Q 1. (a) State Newton's first law of motion. **2 Marks**

(b) See Fig. 1 for details. A *thin*, straight rod is bent into two straight parts, which are mutually perpendicular: $OA = p$ meter and $AB = q$ meter; it is pinned at point O. A force of magnitude F Newton is applied at the other end B; it makes angle θ with the horizontal. Find the torque of the force F about the point O using vector algebra; you need to resolve all the necessary vectors into components using the unit vectors $\hat{i}, \hat{j}, \hat{k}$. **13 Marks**

(c) A particle rotating on a circular path with an angular velocity of 120 r.p.m (revolution per minute) suddenly starts to decelerate uniformly and comes to at rest after 1 hour. Find the value of the constant angular deceleration. **5 Marks**

Q 2. See Fig. 2 for details. The shaded area i.e. ΔOAB is a right-angled triangle with $|OA| = b$, $|OB| = h$.
(a) Find I_{xx}. (b) Find I_{yy}. (c) Find I_{xy}. **6+6+8 Marks**

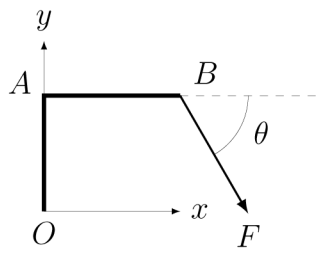

Figure 1: Find the torque of force F about the point O.

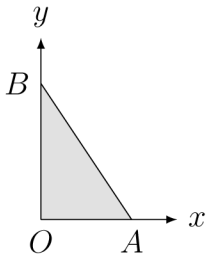

Figure 2: $|OA| = b$, $|OB| = h$; find I_{xx}, I_{yy}, and I_{xy}

Q 3. (a) Fig. 3 shows a metal sheet. Find the coordinates of the centroid of that object using a table (by decomposing the sheet into simpler shapes); all the values shown are in $meter$. **12 Marks**

(b) Consider a thin, flat metallic sheet of area 'A' whose centroid is located at the point O; the x, y axes is a set of centroidal axes. Another set of axes $x^{'}, y^{'}$ is parallel to the former; the origin $O^{'}$ of the later is located at (c, d) with respect to x, y axes. If I_{xx} and I_{yy} are known then find $I_{x'x'}$ and $I_{y'y'}$ in terms of the known quantities. **4+4 Marks**

Q 4. (a) See Fig. 4 for details. A thin, light rod AB of length L is hinged at point B on y axis (it can freely rotate about it); there is a mass M hanging from the midpoint of AB. (i) When the rod makes an angle θ with the wall determine the magnitude of force F (acting along horizontal direction) required to hold the rod in equilibrium. (ii) Determine the x and y components of the force on the rod at the hinge B. **10 Marks**

(b) Redo Q. 4 (a), except, now F acts vertically upwards at point A, unlike the horizontal direction shown in the figure. **10 Marks**

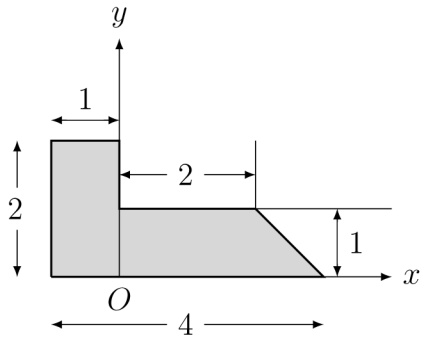

Figure 3: Find the coordinates of the centroid. Values are in $meter$.

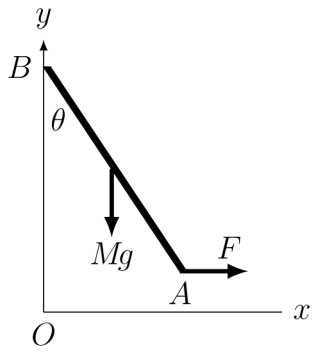

Figure 4: Find F and reactive forces at B in terms of known quantities.

Q 5. (a) At the moment $t = 0$, a particle of mass m starts moving due to a force $F = F_0 \cos(\omega t)$, where F_0 and ω are constants. Find the distance covered by the particle as a function of t. Draw the approximate plot of the function. **10 Marks**

(b) A body of mass 5 kg moving with a velocity of 12 m/s impinges directly on a mass of 10 kg moving with a velocity of 6 m/s in the same direction and adheres to it. Find the velocity of the compound body. **10 Marks**

Q 6. A particle of mass 2 kg moves on the $x - y$ plane; its position vector (in meter) varies with time (in second) as:

$$\vec{r}(t) = 3\sin(2\pi t/3)\,\hat{i} + 4\exp(-3t^2)\,\hat{j}$$

(a) Find how the velocity and acceleration vectors vary with time. **3 Marks**
(b) Find the change in its kinetic energy from 2 to 3 sec. **4 Marks**
(c) Find the work done from 2 to 3 sec and check whether it is the same as the change in kinetic energy or not. **10 Marks**
(d) Draw the 'x-coordinate' vs 'time' graph. **3 Marks**

Q 7. (a) (i) A point moves on a plane; its position is given in polar coordinates (r, θ). Write its rectangular Cartesian coordinates (i.e. x and y) in terms of r and θ. (ii) If its position is given in Cartesian coordinates (x, y), write its polar coordinates (i.e. r and θ) in terms of x and y. **3 Marks**

(b) (i) What is work? (ii) What is power ? (iii) What is torque ? (iv) What is kinetic energy of a moving particle? **6 Marks**

(c) (i) What is linear momentum of a moving body? (ii) What is angular momentum of a rotating body? **3 Marks**

(d) (i) What is the distance a point moves in 3 seconds with constant velocity 5 m/s? (ii) A force of 10 Newton is acting on a body of mass 10 gram. What is its acceleration? **3 Marks**

(e) (i) What is the distance a particle (starting from rest) travels in 4 seconds with constant acceleration 5 m/s^2 ? (ii) What will be its velocity after traveling a distance of 10 m from the initial point ? **5 Marks**