University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATIONS - 2008/2009

School of Electrical, Electronic and Mechanical Engineering

MEEN10030 Mechanics for Engineers

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Dr Liang Cui

Time Allowed: 2 hours

Instructions for Candidates

Answer Question 1 and any four other questions.
All questions carry equal marks. All parts of each question carry equal marks unless otherwise indicated.

Instructions for Invigilators

Non-programmable calculators are permitted.
No rough-work paper is to be provided for candidates.

QUESTION 1

(i) A vector $\mathbf{U} = 3\mathbf{i} - 4\mathbf{j} + 12\mathbf{k}$. What is its magnitude?

(a) 19
(b) 13
(c) 11
(d) 12.207

(ii) The vector $\mathbf{e} = \frac{1}{3}\mathbf{i} + \frac{2}{3}\mathbf{j} + e_z\mathbf{k}$ is a unit vector. What is the component e_z?

(a) $\frac{2}{3}$
(b) 0
(c) $\frac{1}{3}$
(d) 1

(iii) Three vectors

$$\mathbf{U} = U_x\mathbf{i} + 3\mathbf{j} + 2\mathbf{k}$$
$$\mathbf{V} = -3\mathbf{i} + V_y\mathbf{j} + 3\mathbf{k}$$
$$\mathbf{W} = -2\mathbf{i} + 4\mathbf{j} + W_z\mathbf{k}$$

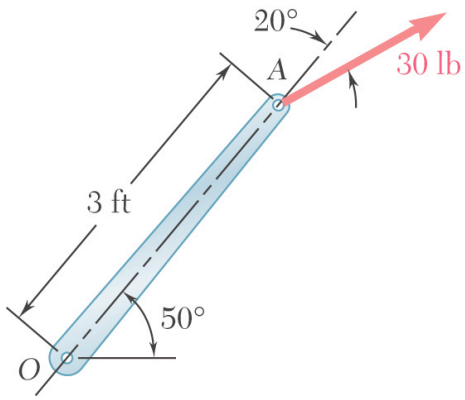
are mutually perpendicular. What are the components U_x, V_y, and W_z?

(a) $U_x = 5$; $V_y = -7$ and $W_z = -5$
(b) $U_x = 4$; $V_y = -6$ and $W_z = -4$
(c) $U_x = 2.857$; $V_y = 0.857$ and $W_z = -3.143$
(d) $U_x = -2.857$; $V_y = -0.857$ and $W_z = 3.143$

(iv) A car weighting 15 kN is parked on a sloped street and the brakes are applied to both its front and rear wheels. If the coefficient of static friction between the car's tyres and the road is $\mu_s = 0.8$, what is the steepest slope (in degrees relative to the horizontal) on which the car could remain in equilibrium?

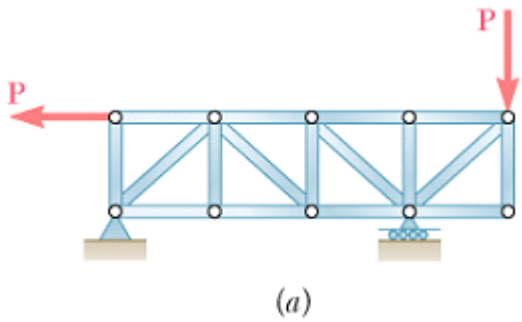
(a) 51.3°
(b) 11.3°
(c) 38.7°
(d) 72.6°

(v) A 30 lb force acts on the end of the 3 ft lever as shown below. What is the moment of the force about O?

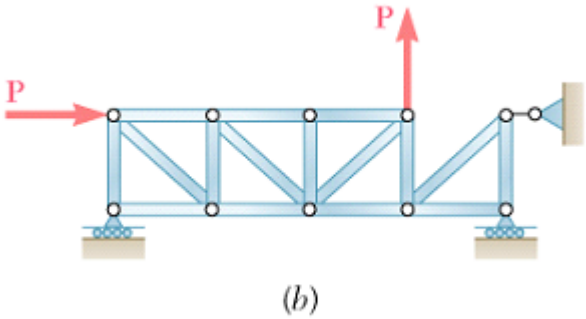


(a) 30.8 lb.ft counter clockwise
(b) 84.6 lb.ft clockwise
(c) 30.8 lb.ft clockwise
(d) 84.6 lb.ft counter clockwise

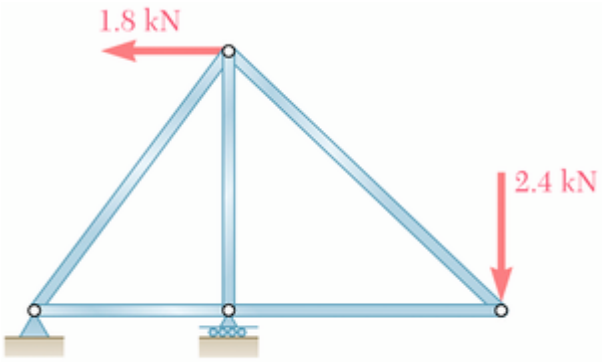
(vi) Which one of the following structures is NOT a truss?



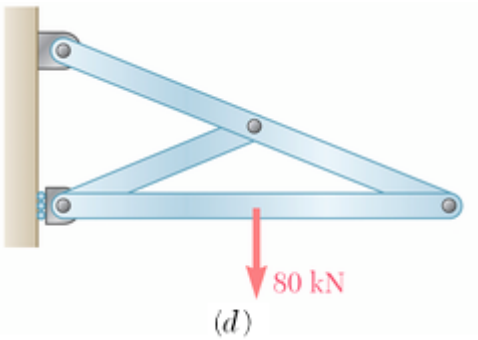
(a)



(b)



(c)



(d)

(vii) Which of the following terms denotes the first moments of an area A with respect to the x axis, i.e. Q_x?

(a) $\int x dA$

(b) $\int y dA$

(c) $\int x^2 dA$

(d) $\int y^2 dA$

(viii) Which of the following statements is TRUE?

(a) The centre of gravity of a plate is always the centroid of the area of the plate.
(b) The centroid of an area is always located in that area.
(c) If an area possesses an axis of symmetry, its centroid is always located on that axis.
(d) None of the above.

(ix) The units for the moment of inertia of a mass is:

(a) kg.m
(b) $kg.m^2$
(c) $N.m^2$
(d) kg/m^2

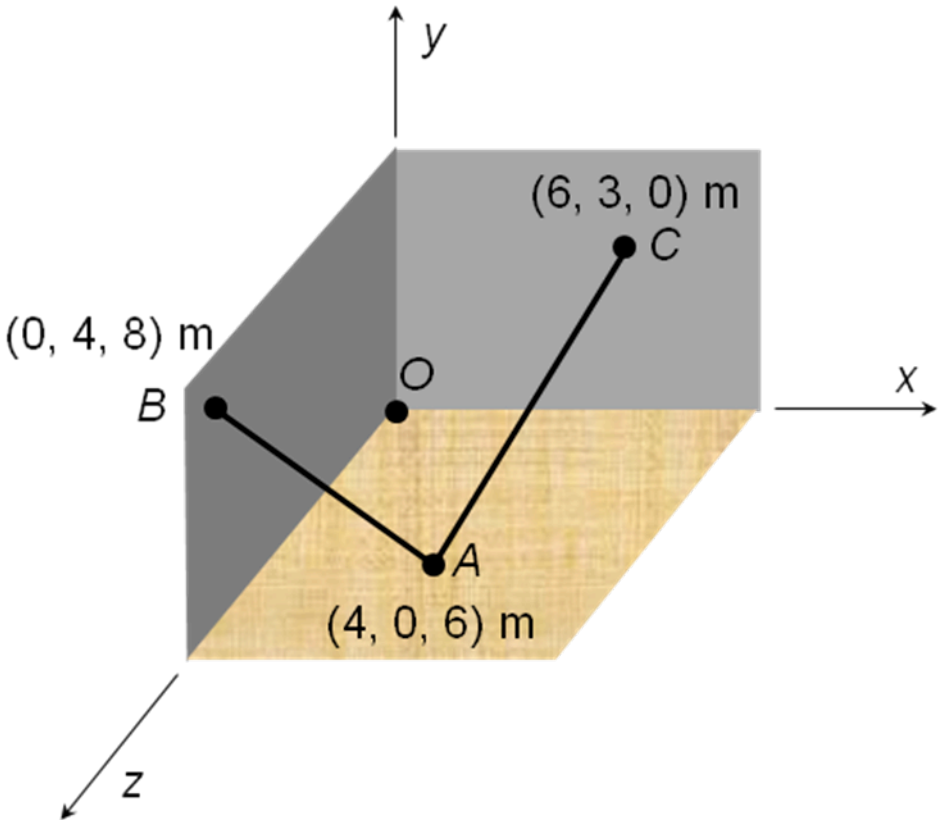
(x) The volume of a body of revolution (V) generated by an area is equal to

(a) $2\pi yA$
(b) $2\pi yL$
(c) πyL
(d) None of the above

where A is the generating area, L is the perimeter of the area, and y is the distance between the centroid of the area and the axis of rotation.

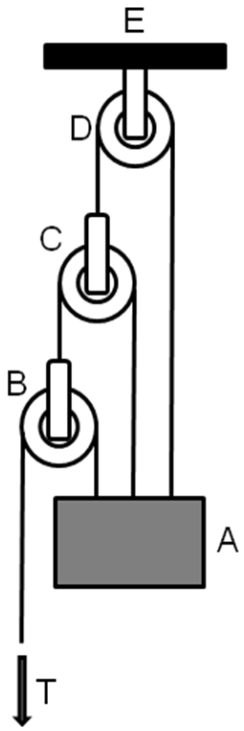
QUESTION 2

The cables *AB* and *AC* extend from an attachment point *A* on the floor to attachment points *B* and *C* in the walls. The tension in cable *AB* is 15 kN, and the tension in cable *AC* is 28 kN. What is the sum of the moments about *O* due to the forces exerted on the attachment point *A* by the two cables?

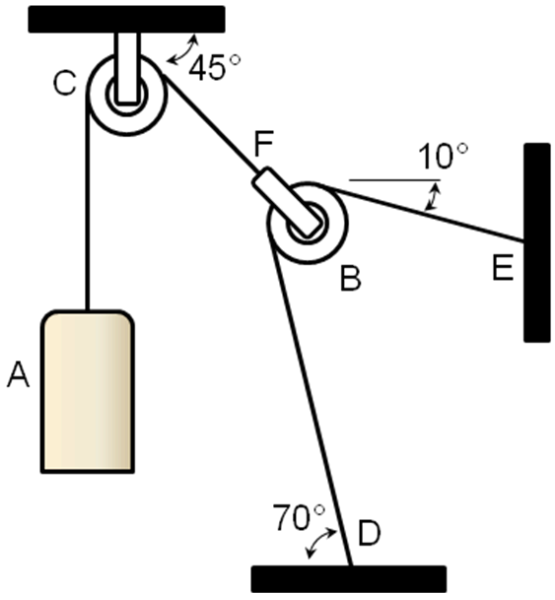


QUESTION 3

(a) This system is in equilibrium. Draw free-body diagrams for each frictionless pulley and the suspended object A and thus establish the relationship between the applied tension T and the weight of object A.

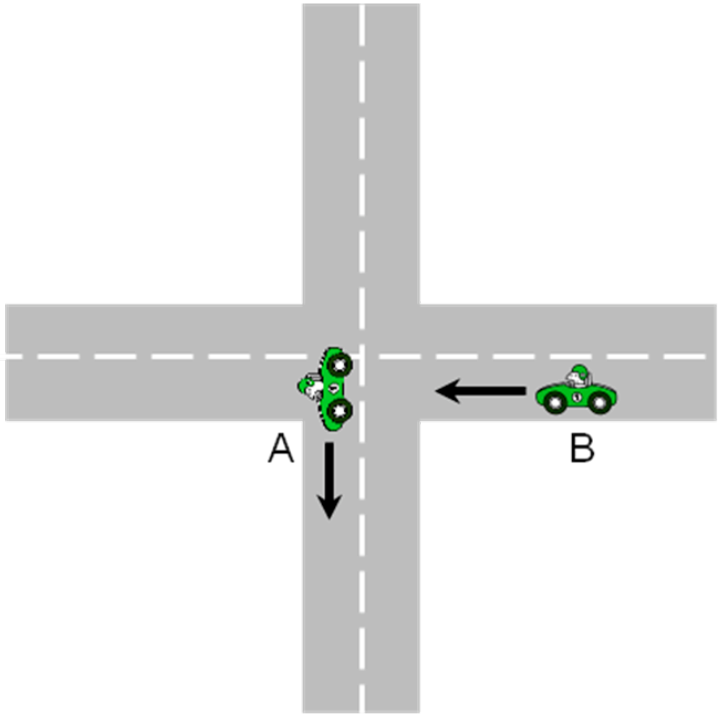


(b) The mass of the cylinder A is 30 kg. Draw free-body diagrams for the cylinder A and the pulley B. Use these free-body diagrams to formulate equilibrium equations for both the cylinder and the pulley and thus find the mass of the pulley B, assuming that the two pulleys are frictionless.



QUESTION 4

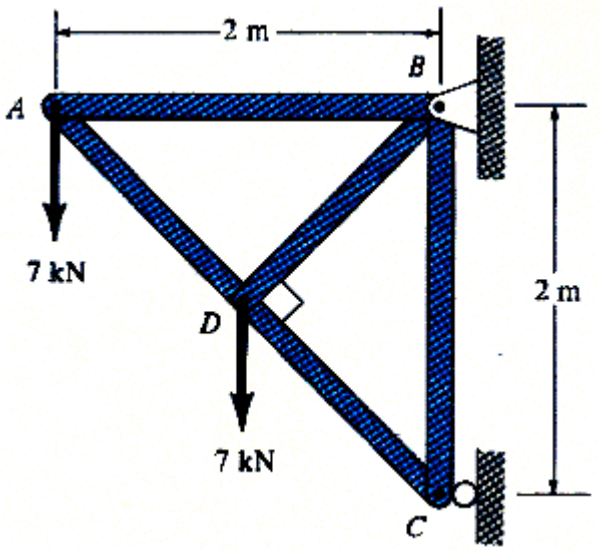
(a) The driver of car A is travelling south at a constant speed of 90 km/hr. As the car passes through the intersection, car B starts to move from rest from a distance of 50 m east of the intersection at a constant acceleration of 3 m/s^2. What are the position, velocity and acceleration of the driver of car B relative to A some 3 seconds after A crosses the intersection.



(b) A motorcyclist is travelling along a curved section of motorway, the radius of curvature of which is 250m, at 180 km/hr and brakes suddenly at a constant deceleration rate upon seeing a police checkpoint. If after 2 seconds, the speed has been reduced to 108 km/hr, what was the acceleration of the motorcyclist immediately after the brakes had been applied?

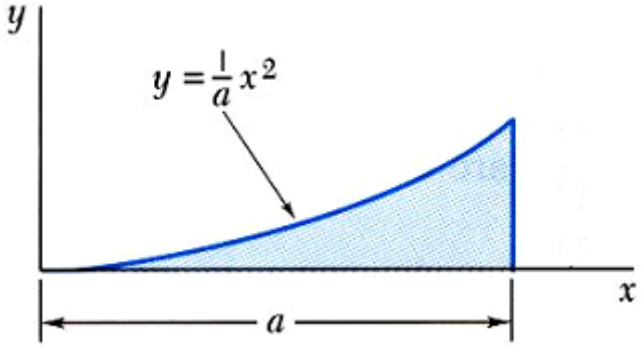
QUESTION 5

Determine the force in each member of the truss and state if the members are in tension or compression.



QUESTION 6

Determine by direct integration the location of the centroid of the following parabolic spandrel.



QUESTION 7

Determine the moment of inertia I_x and I_y of the beam's cross-sectional area with respect to the x axis and y axis as shown:

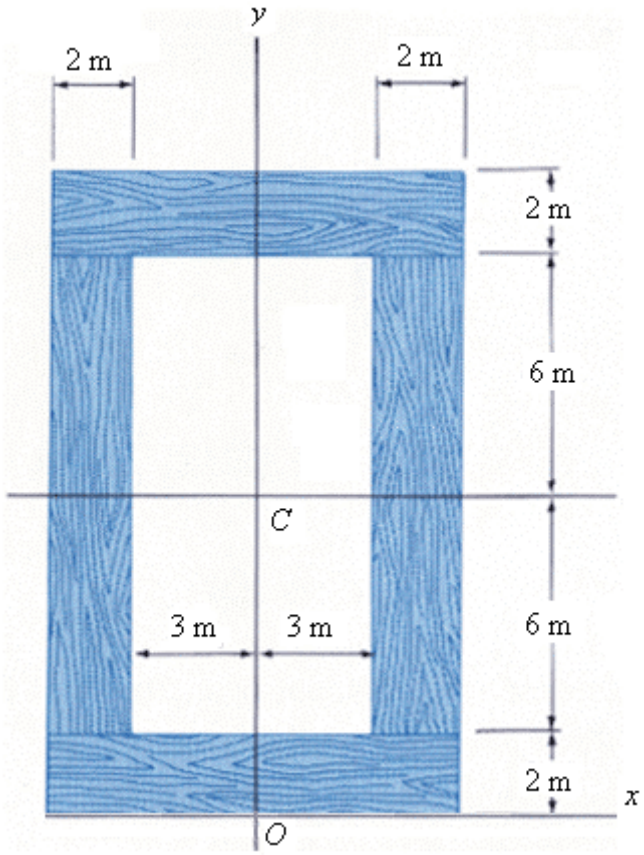
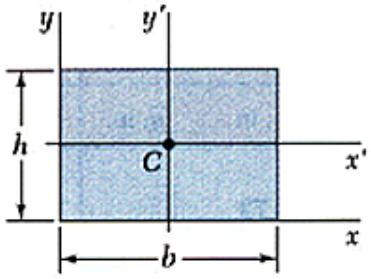
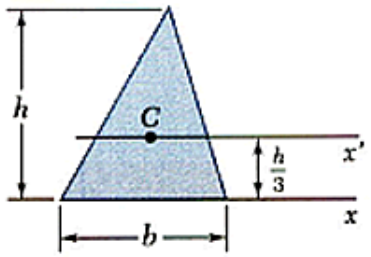
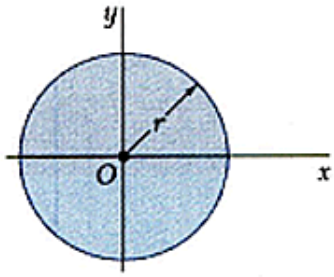
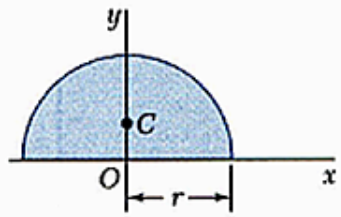
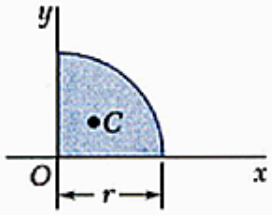
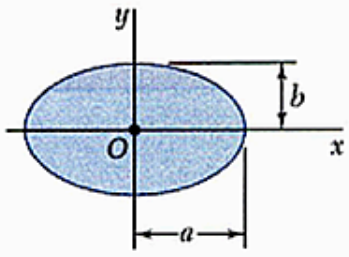


Table 1: Moments of inertia of common geometric shapes

Rectangle		$\bar{I}_{x'} = \frac{1}{12}bh^3$ $\bar{I}_{y'} = \frac{1}{12}b^3h$ $I_x = \frac{1}{3}bh^3$ $I_y = \frac{1}{3}b^3h$ $J_C = \frac{1}{12}bh(b^2 + h^2)$
Triangle		$\bar{I}_{x'} = \frac{1}{36}bh^3$ $I_x = \frac{1}{12}bh^3$
Circle		$\bar{I}_x = \bar{I}_y = \frac{1}{4}\pi r^4$ $J_O = \frac{1}{2}\pi r^4$
Semicircle		$I_x = I_y = \frac{1}{8}\pi r^4$ $J_O = \frac{1}{4}\pi r^4$
Quarter circle		$I_x = I_y = \frac{1}{16}\pi r^4$ $J_O = \frac{1}{8}\pi r^4$
Ellipse		$\bar{I}_x = \frac{1}{4}\pi ab^3$ $\bar{I}_y = \frac{1}{4}\pi a^3b$ $J_O = \frac{1}{4}\pi ab(a^2 + b^2)$

"**oOo**"