University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATIONS – 2012/2013

School of Mechanical & Materials Engineering

MEEN10030 Mechanics for Engineers

Professor Margaret Stack

Professor Michael D. Gilchrist

Dr Aisling Ní Annaidh

Time Allowed: 2 hours

Instructions for Candidates

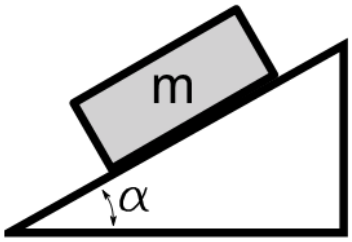
Attempt all questions. All questions carry equal marks. All parts of each question carry equal marks unless otherwise indicated.

Instructions for Invigilators

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

QUESTION 1

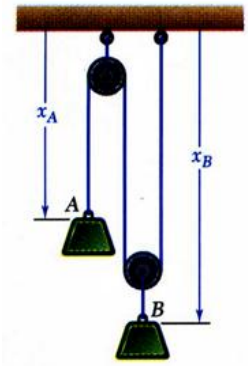
i. A block of mass *m* rests on a slope with an angle *α*. If the coefficient of static friction, *μ*, is 0.4, what is the angle, *α*, beyond which the block will begin to slide?



(a) 66.4°
(b) 31.0°
(c) 21.8°
(d) 23.6°

[2 marks]

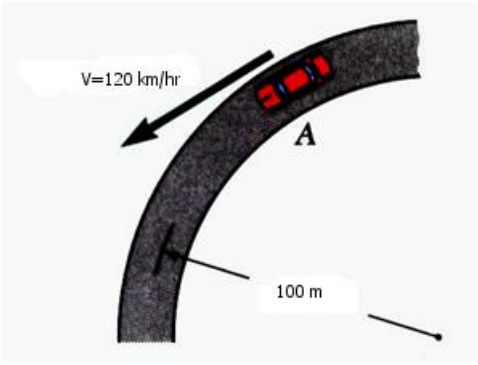
ii. If the velocity of a, v_A = 5 m/s, determine the velocity of b, v_B.



(a) 2.5 m/s
(b) – 2.5 m/s
(c) 10 m/s
(d) -10 m/s

[2 marks]

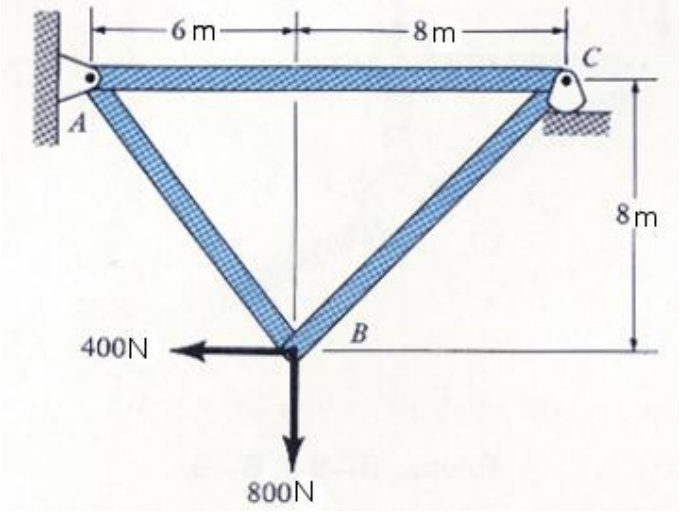
iii. A racing car is moving around a circular track. If its speed is uniformly increased from 100 km/hr to 150 km/hr in 10s, determine the magnitude of the normal component of acceleration while the car's speed is 120 km/hr.



(a) 11.1 m/s^2
(b) 1.39 m/s^2
(c) 0.33 m/s^2
(d) 144 m/s^2

[2 marks]

iv. F Determine the force in member AB of the truss shown below.



(a) 100N
(b) 894N
(c) 286N
(d) 640N

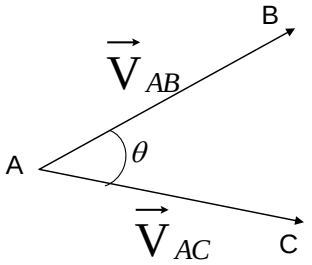
[2 marks]

v. Which of the following denotes the first moments of an area *A* with respect to the *x* axis, i.e. Q_x?

(a) $\int xdA$
(b) $\int y^2dA$
(c) $\int x^2dA$
(d) $\int ydA$

[2 marks]

vi. Two vectors intersect at point A and make an angle θ as shown below. The coordinates of the vectors are as indicated (dimensions are in metres). What is the value of angle θ?



$\vec{V}_{AB} = (3,2,1)m$

$\vec{V}_{AC} = (4,-9,8)m$

(a) θ = 92.42°
(b) θ = 87.50°
(c) θ = 87.58°
(d) θ = 80.58°

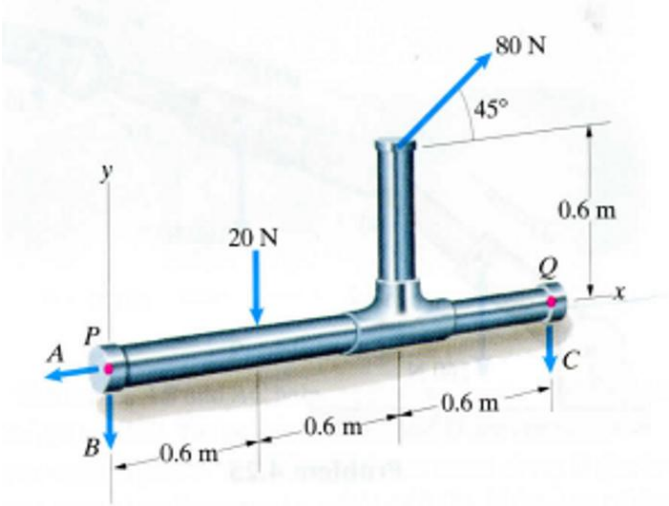
[2 marks]

vii. The components of two vectors **A** and **B** are **A** = -1**i** + 2**j** + 9**k** and **B** = 5**j** + 1**k**. What is the cross product, **A x B**?

(a) 43**i** + 1**j** – 5**k**
(b) -43**i** + 1**j** + 5**k**
(c) -43**i** + 1**j** – 5**k**
(d) 43**i** + 2**j** – 5**k**

[2 marks]

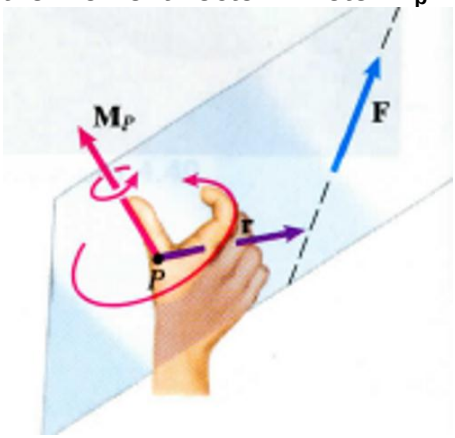
viii. Five forces act on the piping section as shown below. The vector sum of the forces is zero and the sum of the moments of the forces about point P is zero. What is the correct value of force B?



(a) 24.0 N
(b) 5.52 N
(c) -18.08 N
(d) 24.4 N

[2 marks]

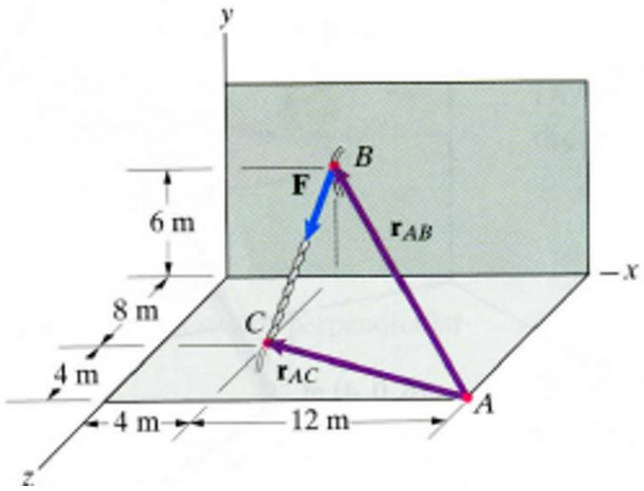
ix. In the sketch below, **M** indicates the moment of the force **F** about the point P as shown in figure. The components of the position and force vectors are given as **r** = 6**i** + 3**j** -9**k** (m) and **F** = 4**i** + 4**j** + 7**k** (N), respectively. What is the magnitude of the moment vector? Note: $\mathbf{M_p} = \mathbf{r} \times \mathbf{F}$.



(a) $|M_p| = 24\mathbf{i} + 12\mathbf{j} - 56\mathbf{k}$
(b) $|M_p| = 62.10$ N.m
(c) $|M_p| = 57\mathbf{i} - 78\mathbf{j} + 12\mathbf{k}$
(d) $|M_p| = 97.35$ N.m

[2 marks]

x. Cable BC exerts a force **F** = 1000 N on the hook at B as shown below. What is the value of the vector $\mathbf{r}_{AB} \times \mathbf{F}$?



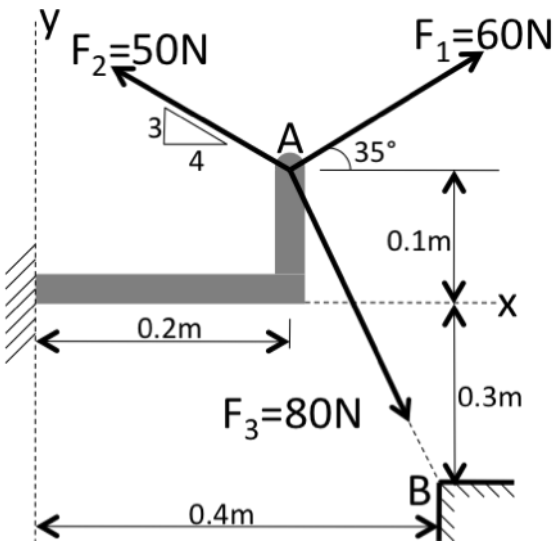
(a) 24000**i** – 9600**j** – 7200**k** (N.m)
(b) -24000**i** + 9600**j** + 7200**k** (N.m)
(c) 2400**i** – 9600**j** – 7200**k** (N.m)
(d) -2400**i** + 9600**j** + 7200**k** (N.m)

[2 marks]

QUESTION 2

(a) The forces $\mathbf{F_1}$, $\mathbf{F_2}$, and $\mathbf{F_3}$ all act on point A of the bracket as shown. Determine the *x* and *y* scalar components of each of the three forces.

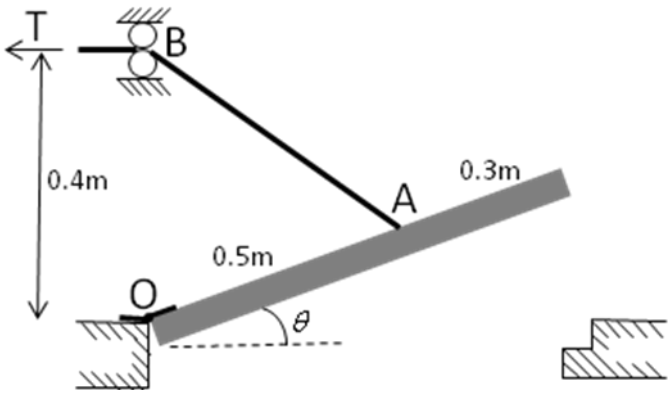
[4 marks]



Question 2(a)

(b) The trap door OA is raised by the cable AB, which passes over the small frictionless guide pulleys at B. The tension everywhere in the cable is T, and this tension applied at A causes a moment M_o about the hinge at O. Plot the quantity M_o/T as a function of the door elevation angle θ over the range $0 \le \theta \le 90°$ and note the minimum and maximum values. What is the physical significance of this ratio?

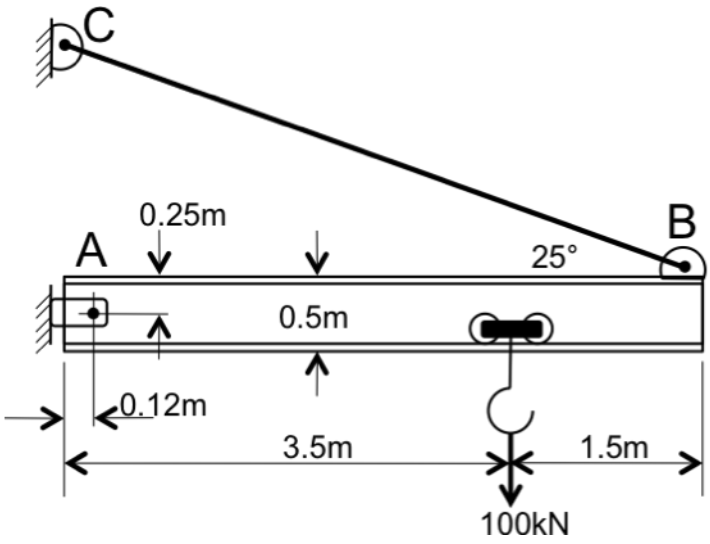
[8 marks]



Question 2(b)

(c) Determine the magnitude T of the tension in the supporting cable BC and the magnitude of the force on the pin at A for the jib crane which carries a load of 100kN as shown. The beam AB is a standard 0.5m tall I-beam of total length 5.0m and a unit mass of 100kg per metre of length.

[8 marks]

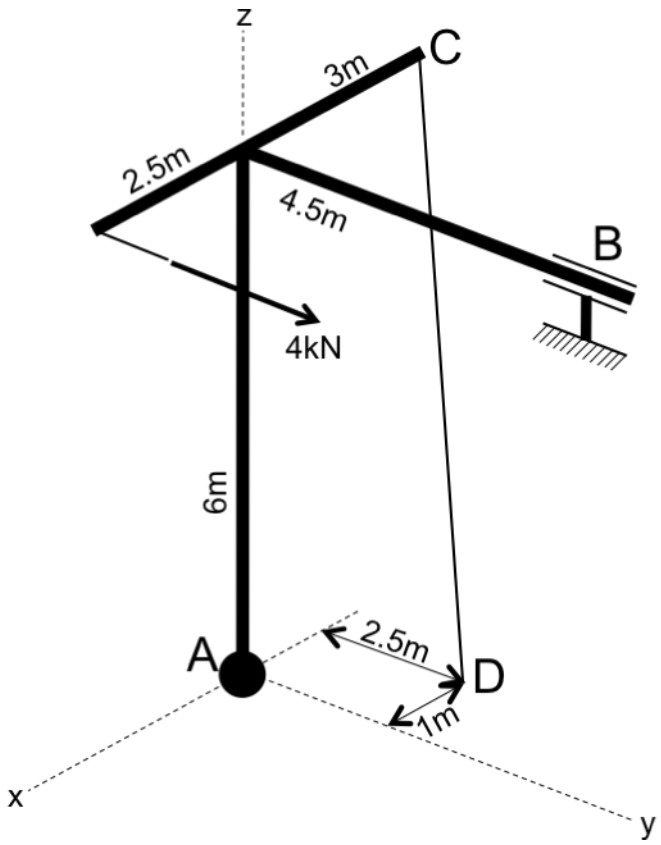


Question 2(c)

QUESTION 3

The welded tubular steel frame is secured to the horizontal *x-y* plane by a ball-and-socket joint at A and receives support from a loose fitting collar at B. Under the action of the 4kN load, rotation about a line from A to B is prevented by the cable CD, and the frame is stable in the position shown below. Neglect the weight of the frame compared with the applied load and determine the tension T in the cable, the reaction at the ring, B, and the reaction components at A.

[20 marks]



Question 3

QUESTION 4

It is observed that a skier leaves the ramp A at an angle θ = 25° with the horizontal.

a) Determine the time, t_{AB} at which the skier strikes point B.

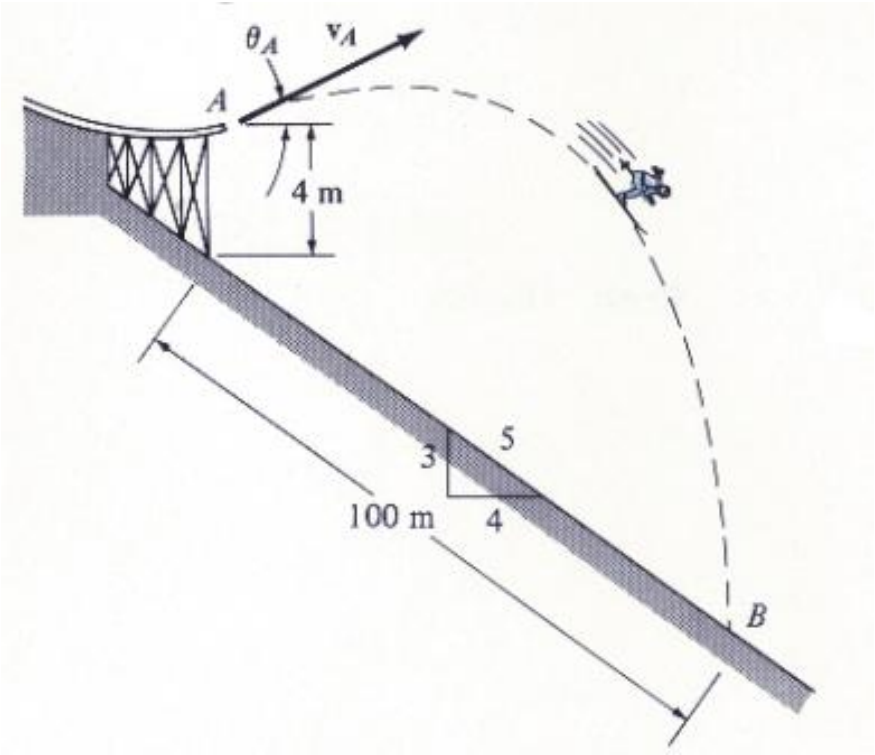
[10 marks]

b) Determine the initial speed v_A.

[5 marks]

c) Determine the highest vertical distance above A that the skier achieves.

[5 marks]



Question 4

QUESTION 5

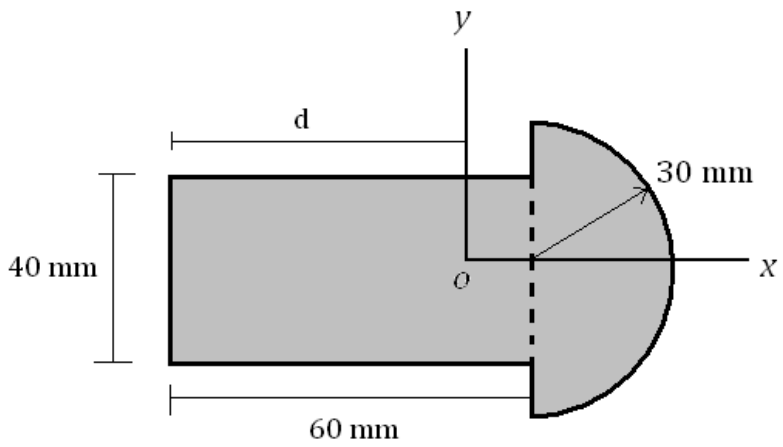
The cross section of the bar indicated below is symmetric about the *x* axis.

(a) Determine *d* so that the origin, *O*, is positioned at the centroid of the area.

[10 marks]

(b) Determine the area moment of inertia about the *y* axis.

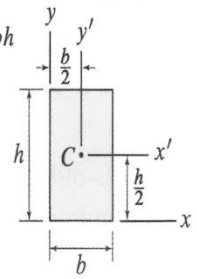
[10 marks]



Question 5

Rectangular Area

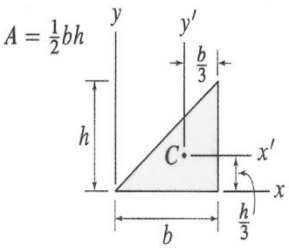
$A = bh$



$I_{x'} = \frac{1}{12}bh^3, I_{y'} = \frac{1}{12}hb^3,$
$I_x = \frac{1}{3}bh^3, I_y = \frac{1}{3}hb^3$

Right Triangular Area

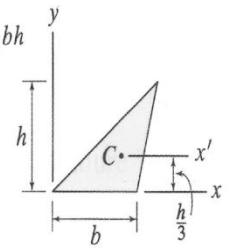
$A = \frac{1}{2}bh$



$I_{x'} = \frac{1}{36}bh^3, I_{y'} = \frac{1}{36}hb^3,$
$I_x = \frac{1}{12}bh^3, I_y = \frac{1}{12}hb^3$

Triangular Area

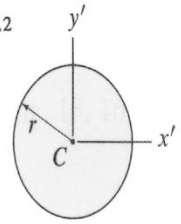
$A = \frac{1}{2}bh$



$I_{x'} = \frac{1}{36}bh^3,$
$I_x = \frac{1}{12}bh^3$

Circular Area

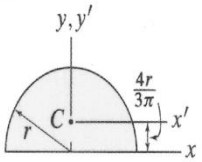
$A = \pi r^2$



$I_{x'} = I_{y'} = \frac{\pi}{4}r^4$
$J_C = \frac{\pi}{2}r^4$

Semicircular Area

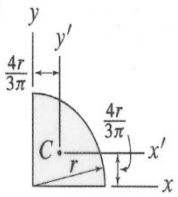
$A = \frac{1}{2}\pi r^2$



$I_{x'} = (\frac{\pi}{8} - \frac{8}{9\pi})r^4, I_{y'} = \frac{1}{8}\pi r^4,$
$I_x = I_y = \frac{1}{8}\pi r^4$

Quarter Circular Area

$A = \frac{1}{4}\pi r^2$



$I_{x'} = I_{y'} = (\frac{\pi}{16} - \frac{4}{9\pi})r^4,$
$I_x = I_y = \frac{1}{16}\pi r^4$

Properties of common geometric shapes

"**oOo**"