University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

SEMESTER I EXAMINATIONS - 2011/2012

School of Mechanical and Materials Engineering

MEEN10030 Mechanics for Engineers

Professor Margaret Stack

Professor Michael Gilchrist

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Time Allowed: 2 hours

Instructions for Candidates

All questions carry equal marks and all questions must be answered. The distribution of marks in the right margin gives an approximate indication of the relative importance of each part of the question.

Instructions for Invigilators

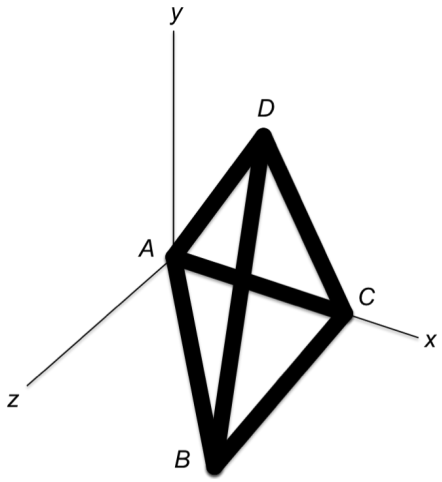
Non-programmable calculators are permitted.
No rough-work paper is to be provided for candidates.

Q1

(i) In Newtonian mechanics, which of the following three are absolute concepts, independent of each other?

(a) Mass, Time, Space
(b) Force, Time, Space
(c) Force, Mass, Time
(d) Force, Mass, Space

(ii) The coordinates of points C and D of the truss are (4, 0, 0) m and (2, 3, 1) m, respectively. What are the direction cosines of the position vector $\mathbf{r}_{CD}$ from point C to point D?

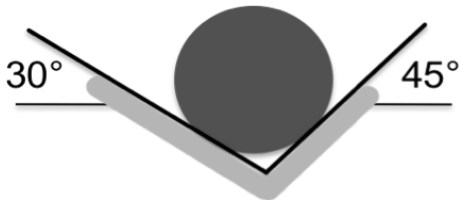


(a) -2**i** + 3**j** + **k** (m)
(b) 2**i** – 3**j** – **k** (m)
(c) cos θ_x = -0.535, cos θ_y = 0.802, cos θ_z = 0.267
(d) cos θ_x = 0.535, cos θ_x = -0.802, cos θ_x = -0.267

(iii) The vectors **U** = **i** + U_y**j** + 4**k**, **V** = 2**i** + **j** – 2**k**, and **W** = -3**i** + **j** – 2**k** are coplanar (i.e., they lie in the same plane). What is the component U_y?

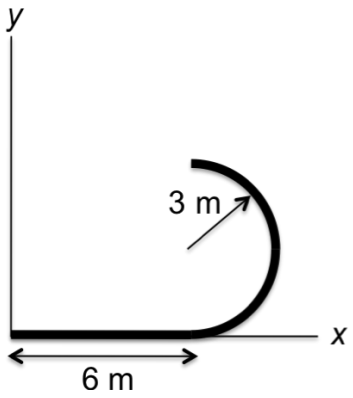
(a) U_y= -4
(b) U_y= +4
(c) U_y= +2
(d) U_y= -2

(iv) The 50 kg cylinder rests on two smooth surfaces. What is the magnitude of the reaction force exerted on the cylinder by the left surface?



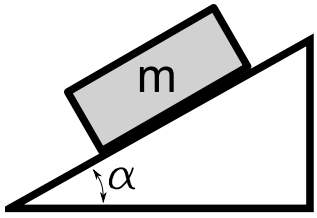
(a) 245 N
(b) 254 N
(c) 359 N
(d) 425 N

(v) What are the coordinates of the centroid of the line indicated below?



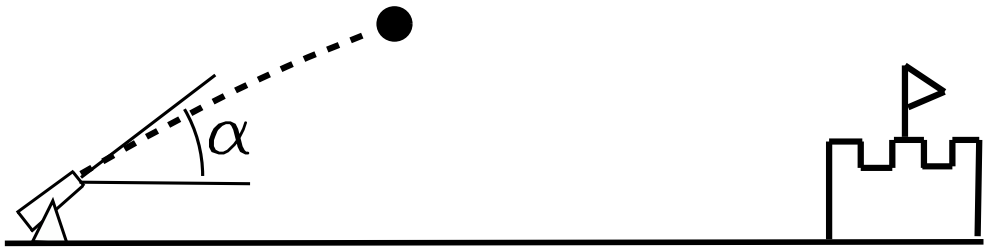
(a) (6, 0) m
(b) (6, 1.83) m
(c) (6, 3) m
(d) (7.27, 1.83) m

(vi) A block of mass *m* rests on a slope with an angle α. The coefficient of static friction between the block and the slope is 0.7. What is the largest slope angle α such that the block does not start to slide down the slope?



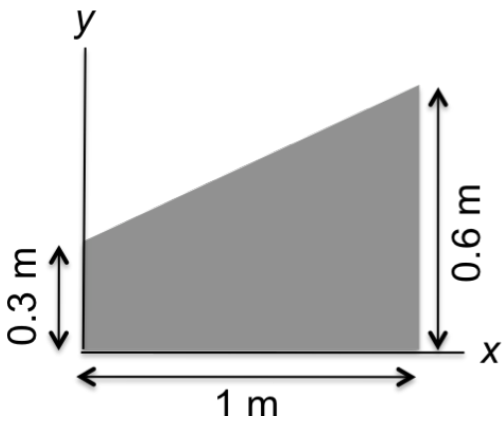
(a) 35°
(b) 44°
(c) 46°
(d) 56°

(vii) A projectile is fired from ground level with angle α = 30° at a speed of 500 km/h and hits the castle which is also at ground level. How long will it take to reach the castle?



(a) 50s
(b) 36s
(c) 28s
(d) 14s

(viii) What is the moment of inertia about the y-axis, I_y, of this shaded shape?



(a) 0.175 m^4
(b) 0.175 m^2
(c) 0.425 m^2
(d) 0.181 m^4

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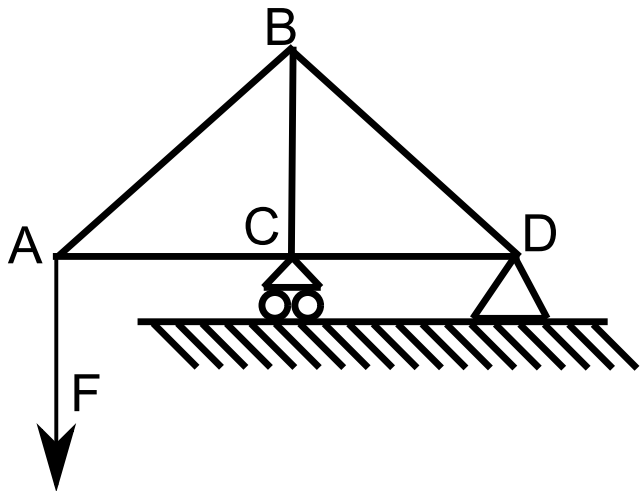
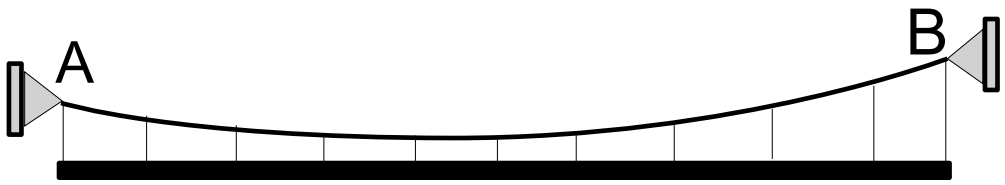
(ix) The truss shown below is supported by a roller and a pin joint and is loaded by a force *F* as indicated. What is the magnitude of the force on member BD? Is this in tension or compression? Note that the length of members BD = BA and the lenfth of members BC = AC = CD.



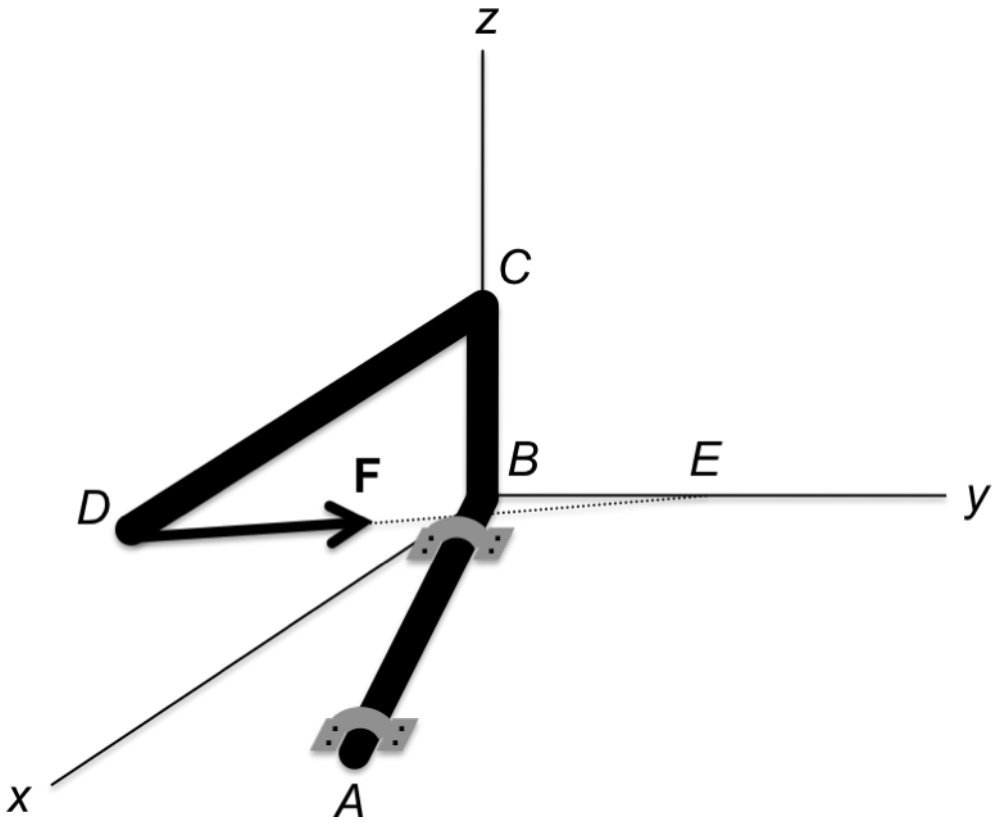
(a) 0.7F; tension
(b) 0.7F; compression
(c) 1.4F; tension
(d) 1.4F; compression

(x) A rod of uniform density and thickness is supported horizontally by a cable which is held between points A and B. Point B is at a higher elevation than point A. Where on the cable is the maximum tension located?



(a) at A
(b) at B
(c) equal and at A and B
(d) at the lowest point on the cable

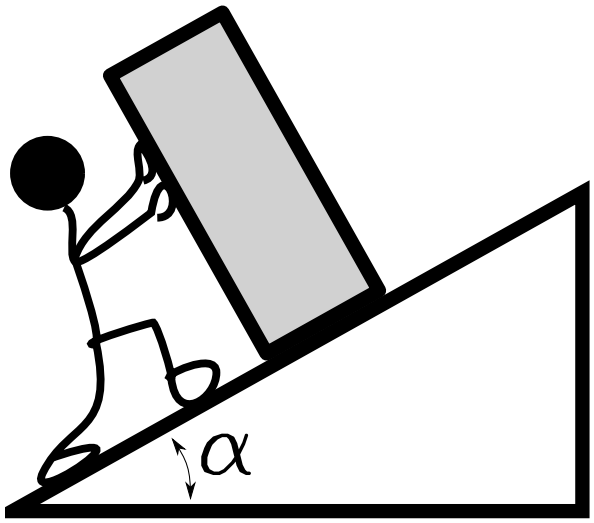
Q2 The solid rod ABCD shown below is supported by two brackets at *A* and *B*. A force **F** acts at end *D* of the rod in a direction pointing towards *E*. Determine the components of the moment $\mathbf{M}_{AB}$ produced by **F** = {-600**i** + 200**j** – 300**k**} N, which tends to rotate the rod about the *AB* axis.



Note that the coordinates of *A*, *B*, *C*, *D* and *E* are as follows:

A = (0.4, 0.2, 0) m
B = (0, 0, 0) m
C = (0, 0, 0.3) m
D = (0.6, 0, 0.3) m
E = (0, 0.2, 0) m

Q3 A man is holding a box which is just about to slide down the slope which has an angle α = 30°. The coefficient of static friction between the box and the slope is 0.4. The mass of the box is 100 kg and the mass of the man is 80 kg. What is the minimum required coefficient of friction between the man's feet and the slope such that the box does not start to slide down the slope?



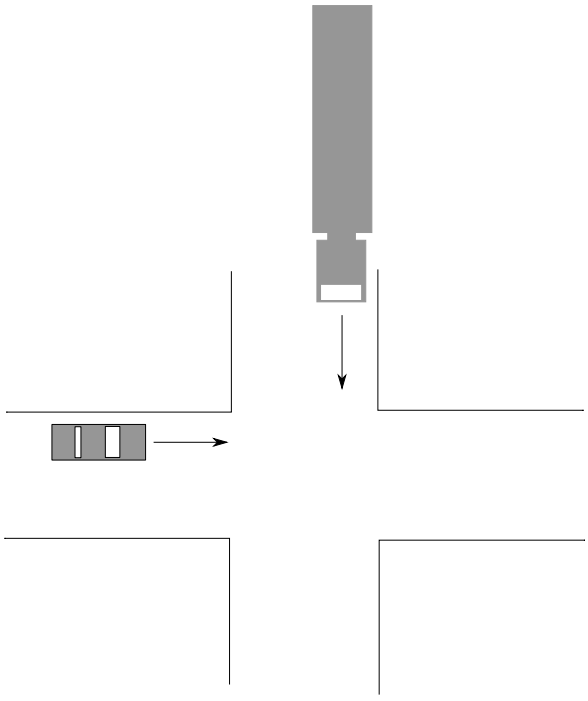
Q4 A car (length 5 m) is moving due east at 60 km/r. A truck (length 15 m) is travelling south at a constant speed of 100 km/h and cannot stop. The car is a distance of 30 m from the road intersection when it applied the brakes, and at the same instant the truck is 40 m from the crossing. At this instant, what is the magnitude and direction of the velocity of the truck as observed from the car? **[4 marks]**

The brakes on the car provide a constant deceleration of 2 m/s^2 when they are applied. Do the car and truck crash? **[6 marks]**

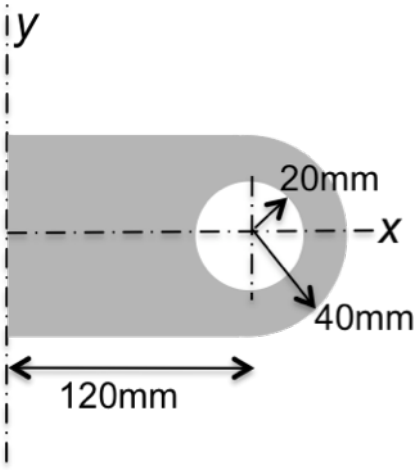
If a collision does occur, who hits the other on the side? Where on the side of the car/truck (measured from the front of the vehicle) is the impact? **[5 + 5 marks]**

If a collision does not occur, what is the distance between them when the first vehicle that reaches the intersection has completely passed the intersection? What is the speed of the car at that instant? **[5 + 5 marks]**

NOTE: Ignore the widths of the car, truck, roads and intersection.



Q5 Determine the moment of inertia and radius of gyration about the y-axis, I_y, for the shaded area shown below:



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