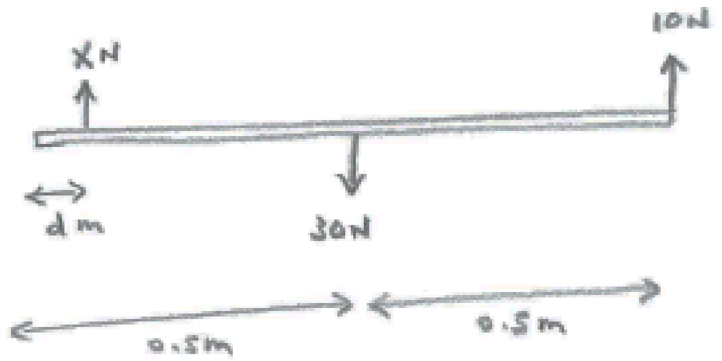
Forces Overview (13/6/23)

Q1 [Practice/E]

If a block of mass m is resting on a surface, prove that the reaction force of the block on the surface is mg.

Q2 [Practice/M]

Vertical forces of X, 30 and 10 N are applied to a light rod of length 1 m, as shown in the diagram. The force of X N is applied at a distance of d m from the left-hand end, and the force of 30N is applied at the mid-point of the rod.

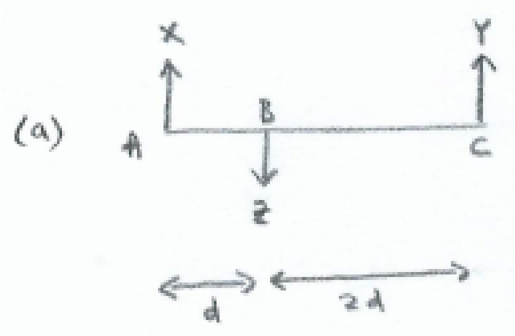


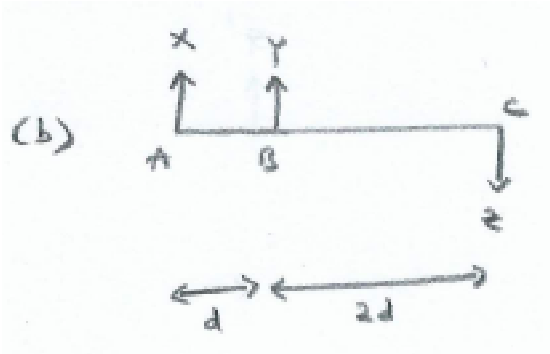
(a) What values must X and d have in order for the rod to be in equilbrium?

(b) The force of X N is removed, and the forces of 30N and 10N are to be replaced with a single force having the same effect as these two forces. What is the size and line of action of this single force?

Q3 [Problem/M]

(i) Which of the following systems of forces could be in equilbrium? (with X, Y and Z > 0)

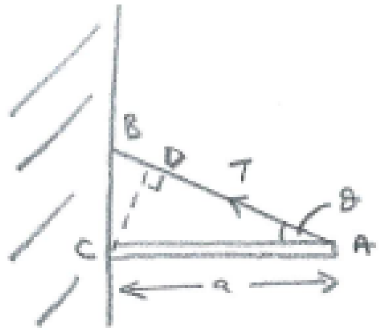




(ii) Assuming that $X + Y = Z$, show that the total moments about A, B and C are equal, in both of the cases in (i).

Q4 [Practice/E]

Show that the moment of T about C is the same:



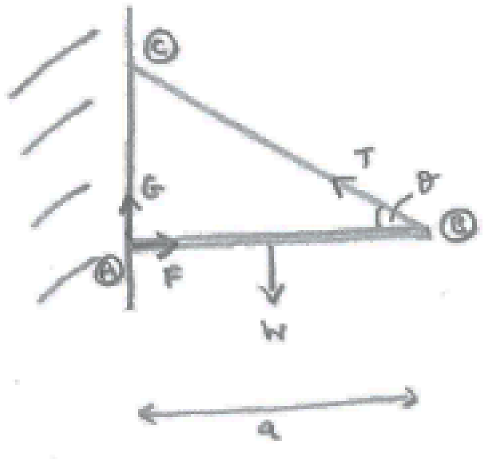
(i) if T is multiplied by CD

(ii) T is resolved into horizontal & vertical components at A

(iii) T is resolved into horizontal & vertical components at B

Q5 [Practice/M]

[Alternative Moments Methods]



A rod AB is attached to a wall at A, and held in a horizontal position by a rope BC.

Show that, as an alternative to resolving forces horizontally and vertically, and taking moments about A, it is also possible to:

(a) resolve forces horizontally and take moments about A & B,

or (b) take moments about A, B & C;

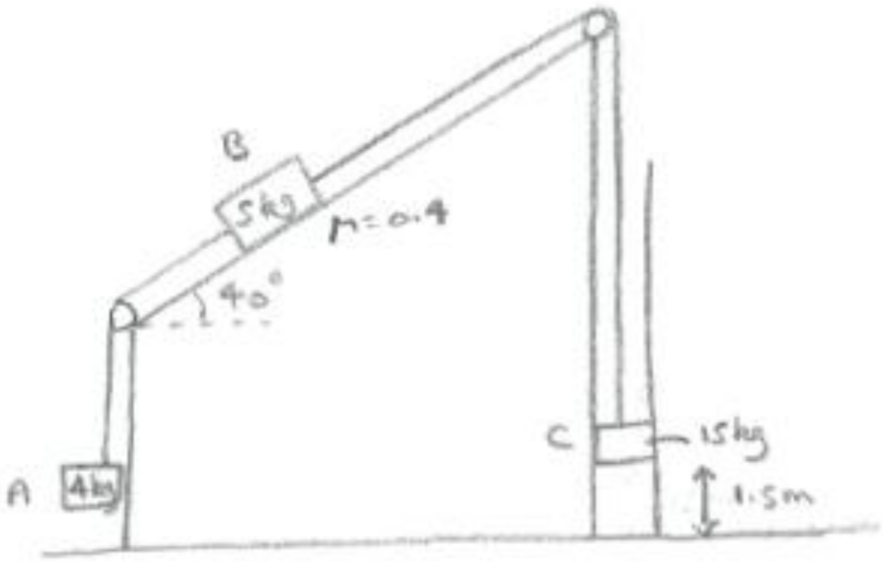
but that it is not possible to do the following:

(c) resolve forces vertically and take moments about A & B,

or (d) take moments about A, B & the midpoint of AB

Q6 [13 marks]

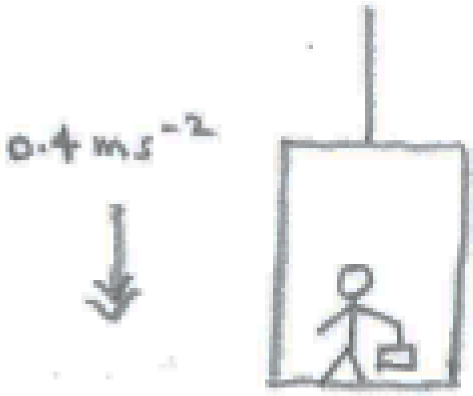
Referring to the diagram below, A has mass $4kg$ and hangs freely, B has mass $5kg$ and moves on a rough slope which makes an angle $40°$ with the horizontal, with a coefficient of friction of 0.4, and C has mass $15kg$ and slides in a groove, against a constant frictional force of $15N$. The objects are connected by light inextensible ropes, which pass over smooth pegs. Initially C is $1.5m$ above the ground.



The system is released from rest. Find how far up the slope B travels. It can be assumed that A and B don't reach the next peg, and that the rope connecting A and B remains taut. Also, air resistance can be ignored.

Q7 [8 marks]

A man is in a lift, which is moving downwards with an acceleration of $0.4ms^{-1}$. The lift is suspended by a cable, and the man is holding a parcel by a light string, as in the diagram. The masses of the lift, man and parcel are 300kg, 80kg and 5kg, respectively.



(i) Find :

(a) the tension in the cable [2 marks]

(b) the reaction between the man and the floor of the lift

[2 marks]

(c) the tension in the string [2 marks]

(ii) Does the man feel heavier or lighter than he would if the lift were stationary and he were no longer carrying the parcel?

[2 marks]

Q8 [Problem/H]

A stepladder is made up of two sides, which have weights 80N and 8N. Both sides are of length 2m. There is a platform resting on the top, which together with a person standing on it weighs 700N. The two sides are also joined together by a horizontal light rope of length 1m, which starts at a distance of 0.6m along each side, from the base. See Fig. 1. There is no friction between the ladder and the ground, or between the platform and the ladder. Find the tension in the rope.

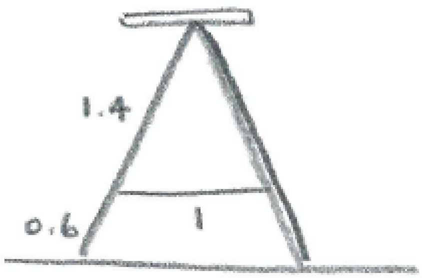


Fig. 1

Q9 [Problem/M]

(i) A lift of mass $400kg$ has a maximum acceleration or deceleration of $1ms^{-2}$, and the lift cable can support a tension of $9000N$. What is the maximum number of people of mass $80kg$ that can safely be carried? (Assume $g = 10ms^{-2}$.)

(ii) If a single person of mass $80kg$ is in the lift when it is accelerating downwards at $1ms^{-2}$, how much lighter does the person feel, compared with their usual weight, as a percentage?