Forces - Exercises (8 pages; 6/4/20)

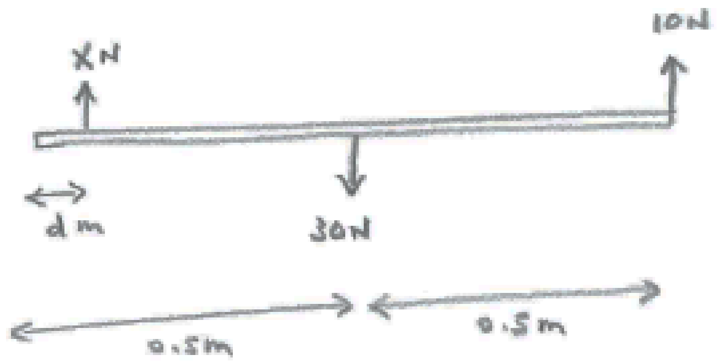
Key to difficulty:

* easier

** moderate

*** harder

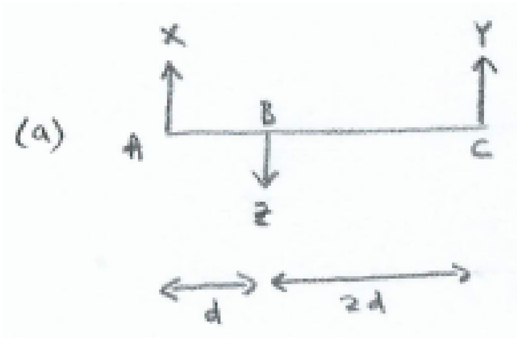
(1**) Vertical forces of X, 30 and 10 N are applied to a light rod of length 1 m, as shown in the diagram. The force of X N is applied at a distance of d m from the left-hand end, and the force of 30N is applied at the mid-point of the rod.



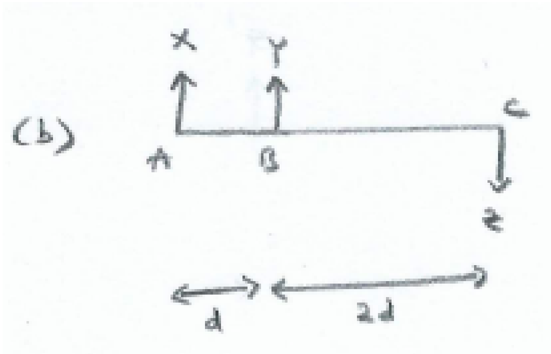
(a) What values must X and d have in order for the rod to be in equilbrium?

(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?

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



(ii)

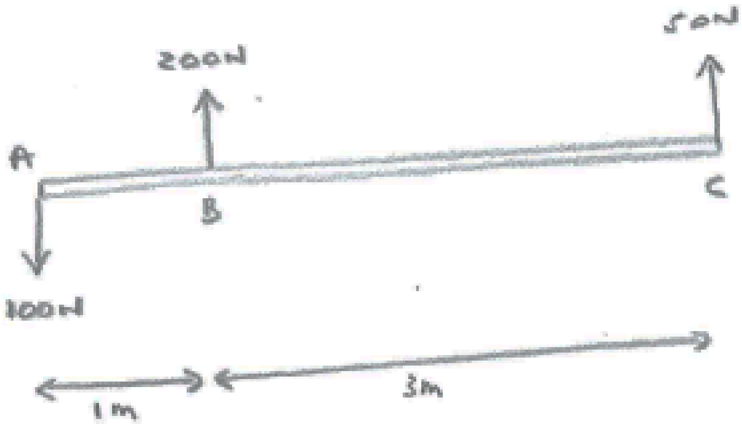


Assuming that $X + Y = Z$, show that the total moments about A, B and C are equal, in both of the cases in (i).

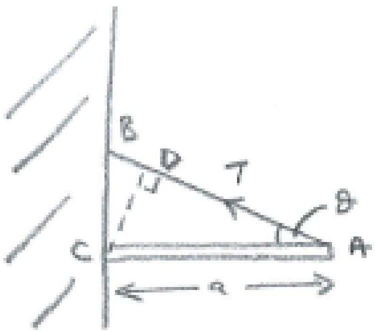
(3**) Forces are applied to a light rod, as shown in the diagram.

(a) Find the magnitude and line of action of the additional force that would be needed in order for the rod to be in equilibrium.

(b) Find the magnitude and line of action of the single force that has the same effect as the forces in the diagram.



(4**)



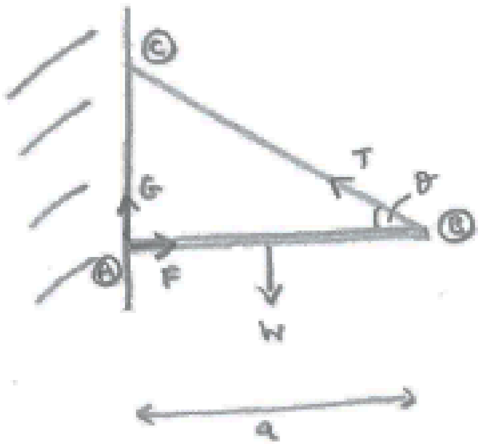
Show that the moment of T about C is the same:

(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

(5**) 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:

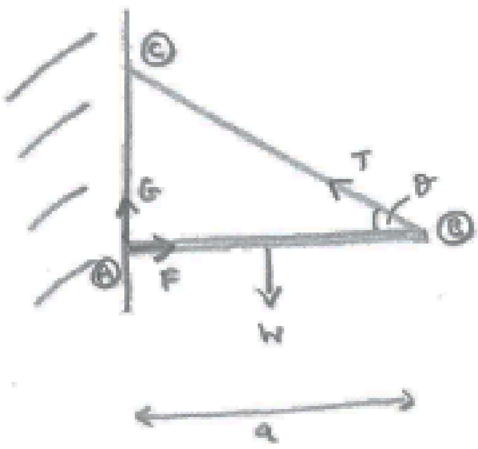
(a) resolve forces horizontally and take moments about A & B, or (b) take moments about A, B & C;

but that it is not possible to do the following:

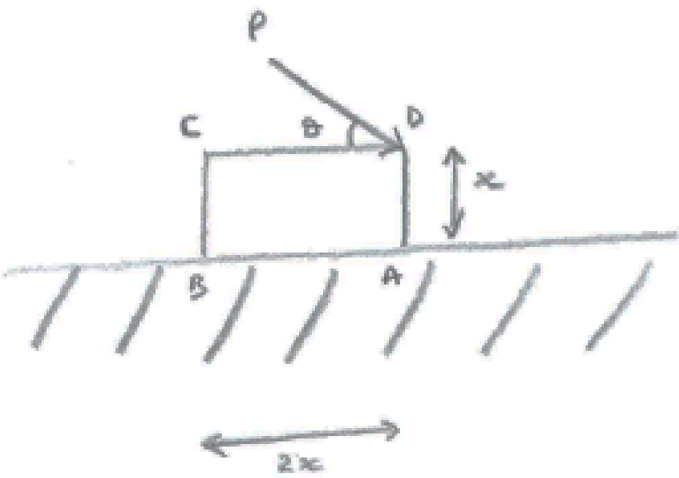
(c) resolve forces vertically and take moments about A & B,

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

(6*) Referring to the diagram below, about which point should moments be taken, in order to find F in terms of W?



(7***) A uniform block of mass m rests on a table, and a force P is applied at D, as shown in the diagram. The block has length $2x$ and height x. The coefficient of friction between the block and the table is μ.

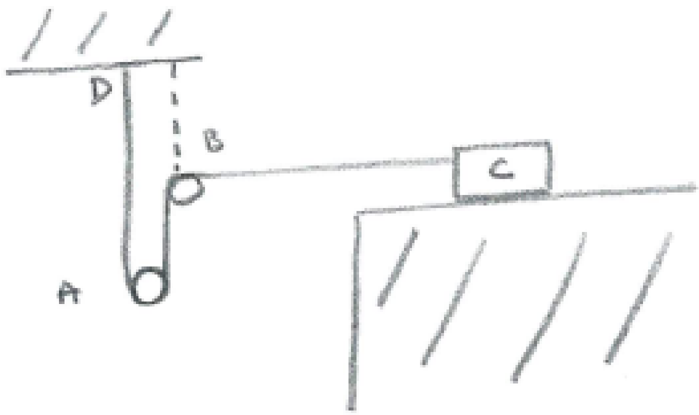


(i) If the block is on the point of sliding, find an expression for P.

(ii) If instead the block is on the point of toppling, find an expression for P.

(iii) If the block is to topple before it slides, find a condition on μ.

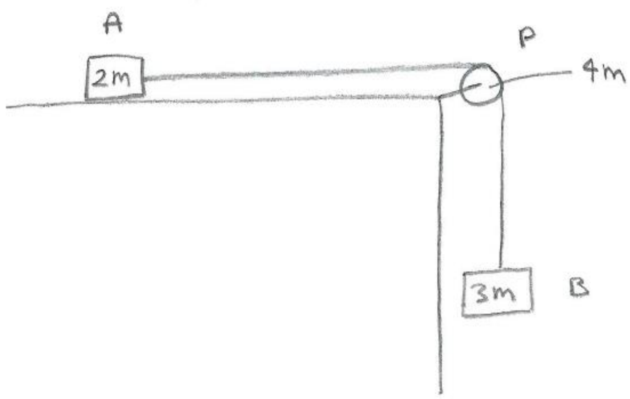
(8***)



Referring to the diagram, A is a smooth pulley of mass 2 kg, which can move up and down; B is a smooth, fixed pulley, and C is a block of mass 1kg, which is initially held at rest on a table. A light inextensible rope is fixed at D, and leads to C, via the two pulleys.

C is now released and accelerates at 2 ms^{-1}. Find the coefficient of friction, μ between C and the table.

(9***) Rotating Pulley



Initially block A is held at rest on a smooth table. The pulley P can rotate freely. The string leading from A to B, passing over P, is light and inextensible.

The pulley is a uniform disc of radius r, and the blocks can be modelled as particles.

Block A is released. The tension in the section of the string AP is T_A and in PB it is T_B.

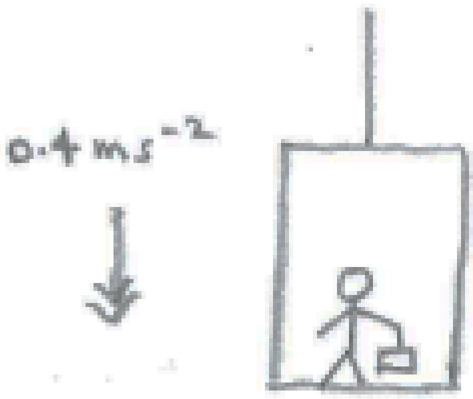
Assuming that the string does not slip on the pulley, and that A does not reach P,

(i) Show that the angular acceleration of the pulley is $\frac{3g}{7r}$ $rads^{-2}$

(ii) Find T_A and T_B in terms of m and g.

(10***) Forces

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

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

(c) the tension in the string

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

(11**) A sledge with a child onboard is being pulled along on level ground, at a constant speed, by means of a rope inclined at 30° to the horizontal. The sledge and child together have a mass of $100kg$. The coefficient of friction between the sledge and the ground is $\frac{1}{10}$. Assuming that $g = 10$, find the tension in the rope.

(12***) A uniform solid hemisphere rests in equilibrium on a rough slope, with its curved surface in contact with the slope, which is inclined at an angle α to the horizontal, in such a way that the plane face of the hemisphere is vertical. Find α.

(13***) 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.

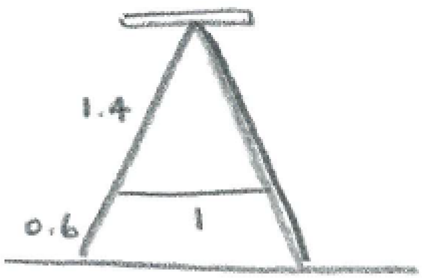


Fig. 1

(14***) [from Wragg: "Modern Mechanics - A vectorial approach"]

A uniform rod AB lies in equilibrium between two smooth planes inclined at angles α and β to the horizontal, as shown in the diagram, where $\beta > \alpha$, such that the vertical plane containing AB is perpendicular to the line of intersection of the two planes.

(i) Show that the ratio of the reactions at A and B is $sin\beta: sin\alpha$

(ii) If AB makes an angle θ to the horizontal, show that

$tan\theta = \frac{\sin(\beta-\alpha)}{2sin\alpha sin\beta}$