Exam Questions – A2 Moments Chapter 4

Q1.

A non-uniform plank *AB* has length 6 m and mass 30 kg. The plank rests in equilibrium in a horizontal position on supports at the points *S* and *T* of the plank where *AS* = 0.5 m and *TB* = 2 m.

When a block of mass *M* kg is placed on the plank at *A*, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about *S*.

When the block is moved to *B*, the plank remains horizontal and in equilibrium and the plank is on the point of tilting about *T*.

The distance of the centre of mass of the plank from *A* is *d* metres. The block is modelled as a particle and the plank is modelled as a non-uniform rod. Find

(i) the value of *d*,

(ii) the value of *M*.

(7)

(Total for question = 7 marks)

Q2.

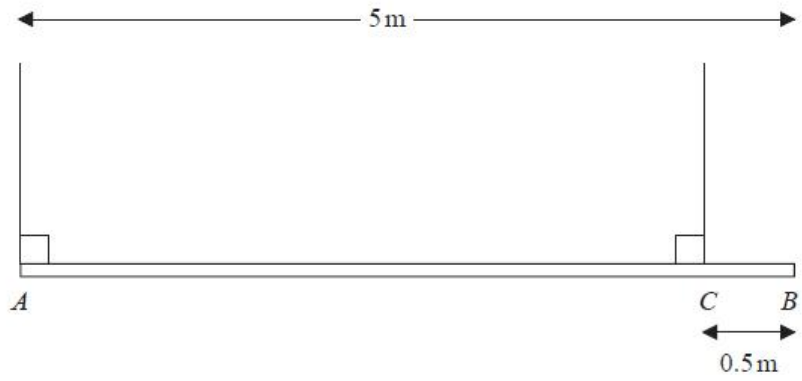

Figure 3

A beam *AB* has length 5 m and mass 25 kg. The beam is suspended in equilibrium in a horizontal position by two vertical ropes. One rope is attached to the beam at *A* and the other rope is attached to the point *C* on the beam where *CB* = 0.5 m, as shown in Figure 3. A particle *P* of mass 60 kg is attached to the beam at *B* and the beam remains in equilibrium in a horizontal position. The beam is modelled as a uniform rod and the ropes are modelled as light strings.

(a) Find

(i) the tension in the rope attached to the beam at *A*,
(ii) the tension in the rope attached to the beam at *C*.

(6)

Particle P is removed and replaced by a particle Q of mass M kg at B. Given that the beam remains in equilibrium in a horizontal position,

(b) find

(i) the greatest possible value of M,
(ii) the greatest possible tension in the rope attached to the beam at C.

(6)

(Total for question = 12 marks)

Q3.

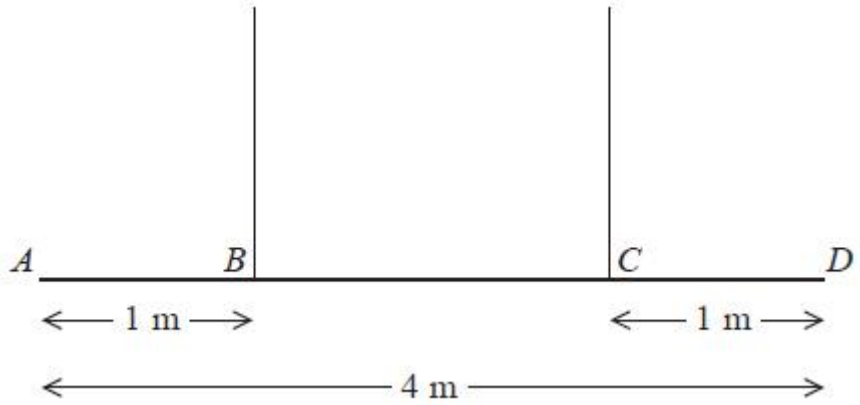

Figure 3

A non-uniform beam AD has weight W newtons and length 4 m. It is held in equilibrium in a horizontal position by two vertical ropes attached to the beam. The ropes are attached to two points B and C on the beam, where AB = 1 m and CD = 1 m, as shown in Figure 3. The tension in the rope attached to C is double the tension in the rope attached to B. The beam is modelled as a rod and the ropes are modelled as light inextensible strings.

(a) Find the distance of the centre of mass of the beam from A.

(6)

A small load of weight kW newtons is attached to the beam at D. The beam remains in equilibrium in a horizontal position. The load is modelled as a particle.

Find

(b) an expression for the tension in the rope attached to B, giving your answer in terms of k and W,

(3)

(c) the set of possible values of k for which both ropes remain taut.

(2)

(Total 11 marks)

Q4.
A steel girder AB, of mass 200 kg and length 12 m, rests horizontally in equilibrium on two smooth supports at C and at D, where $AC = 2$ m and $DB = 2$ m. A man of mass 80 kg stands on the girder at the point P, where $AP = 4$ m, as shown in Figure 1.

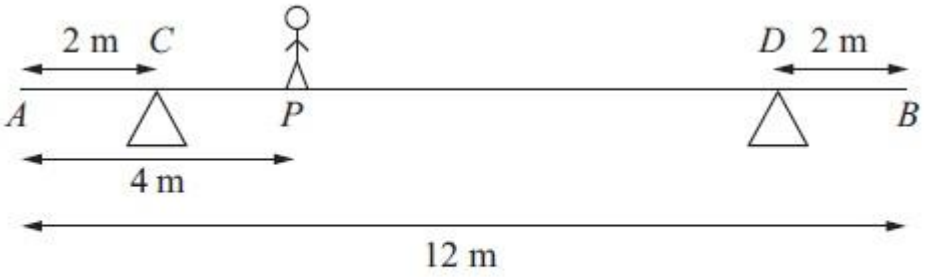

Figure 1

The man is modelled as a particle and the girder is modelled as a uniform rod.

(a) Find the magnitude of the reaction on the girder at the support at C.

(3)

The support at D is now moved to the point X on the girder, where $XB = x$ metres. The man remains on the girder at P, as shown in Figure 2.

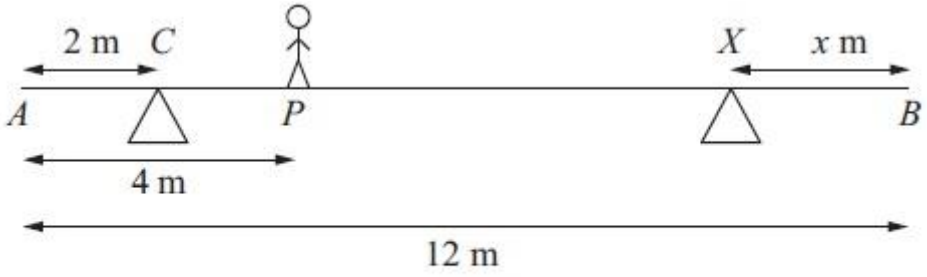

Figure 2

Given that the magnitudes of the reactions at the two supports are now equal and that the girder again rests horizontally in equilibrium, find

(b) the magnitude of the reaction at the support at X,

(2)

(c) the value of x.

(4)

(Total 9 marks)

Q5.

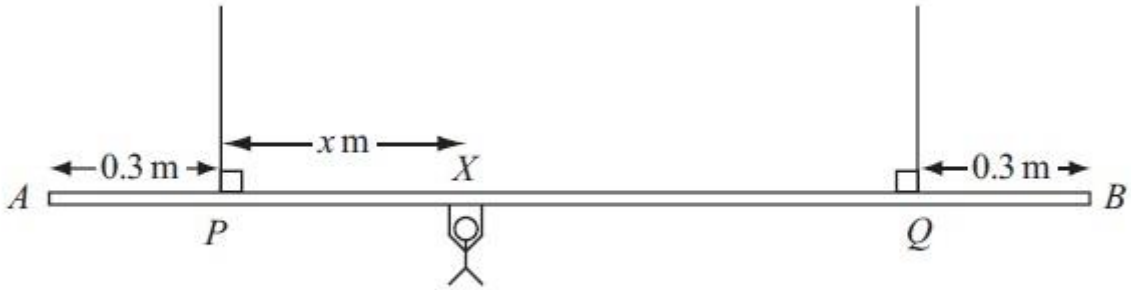

Figure 2

A beam *AB* is supported by two vertical ropes, which are attached to the beam at points *P* and *Q*, where *AP* = 0.3 m and *BQ* = 0.3 m. The beam is modelled as a uniform rod, of length 2 m and mass 20 kg. The ropes are modelled as light inextensible strings. A gymnast of mass 50 kg hangs on the beam between *P* and *Q*. The gymnast is modelled as a particle attached to the beam at the point *X*, where *PX* = *x* m, $0 < x < 1.4$ as shown in Figure 2. The beam rests in equilibrium in a horizontal position.

(a) Show that the tension in the rope attached to the beam at *P* is $(588 - 350x)$ N.

(3)

(b) Find, in terms of *x*, the tension in the rope attached to the beam at *Q*.

(3)

(c) Hence find, justifying your answer carefully, the range of values of the tension which could occur in each rope.

(3)

Given that the tension in the rope attached at *Q* is three times the tension in the rope attached at *P*,

(d) find the value of *x*.

(3)

(Total 12 marks)

Q6.

A beam AB has length 15 m. The beam rests horizontally in equilibrium on two smooth supports at the points P and Q where AP = 2 m and QB = 3 m. When a child of mass 50 kg stands on the beam at A, the beam remains in equilibrium and is on the point about tilting about P. When the same child of mass 50 kg stands on the beam at B, the beam remains in equilibrium and is on the point about tilting about Q. The child is modelled as a particle and the beam is modelled as a non-uniform rod.

(a) (i) Find the mass of the beam.
(ii) Find the distance of the centre of mass of the beam from A.

(8)

When the child stands at the point X on the beam, it remains horizontal and in equilibrium. Given that the reactions at the two supports are equal in magnitude,

(b) Find AX.

(6)

(Total 14 marks)