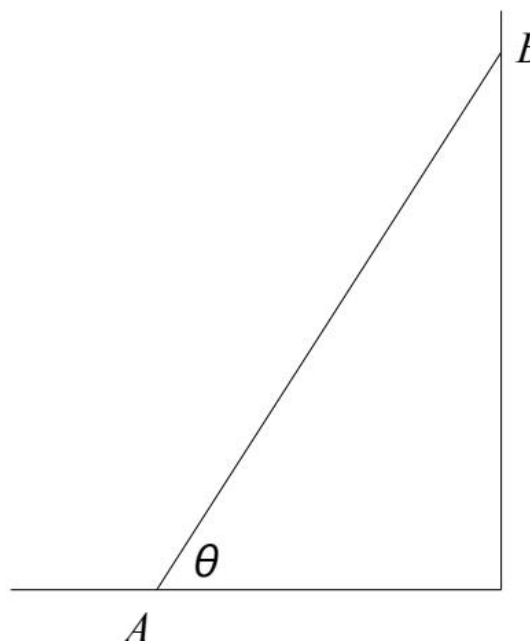


- 1 A uniform ladder AB of mass 20 kg and length 5 m is at rest with one end A on rough horizontal ground and the other end B against a smooth vertical wall. The coefficient of friction between the ladder and the ground is 0.4. The ladder makes an angle θ with the ground.



Given that the ladder is on the point of slipping.

- (a) Find the magnitude of the frictional force of the ground on the ladder

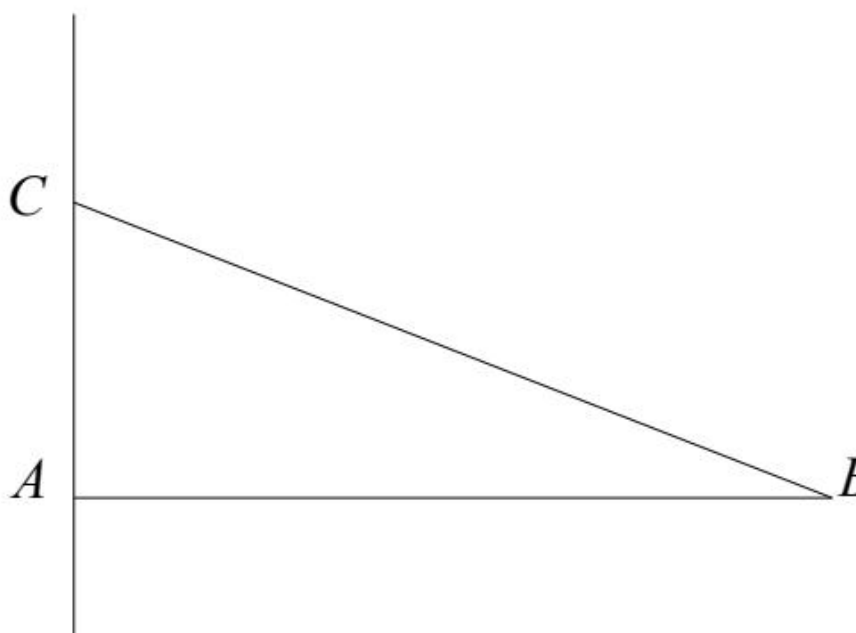
(2)

(b) Find the value of θ , to 1 decimal place.

(5)

(Total for question 1 is 7 marks)

- 2 A uniform rod AB , of length 2 m and mass 3 kg, is smoothly hinged to a vertical wall at A . The rod is held in equilibrium in a horizontal position by a light inextensible string BC , where $AC = 1.5$ m.



- (a) The tension in the string BC

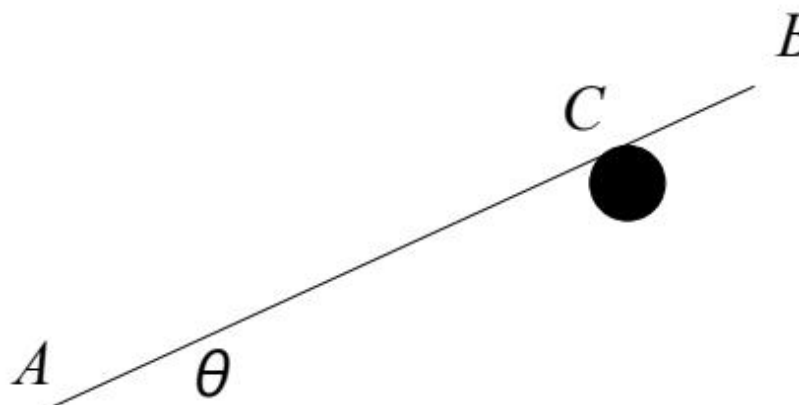
(3)

(b) The magnitude and direction of the force exerted on the rod at A

(6)

(Total for question 2 is 9 marks)

- 3 A uniform rod AB of mass 10 kg and length 6 m rests in equilibrium with A on rough horizontal ground. The rod is resting on a smooth peg at C , where $AC = 4\text{ m}$. The angle between AB and the ground is θ , where $\tan \theta = 0.4$

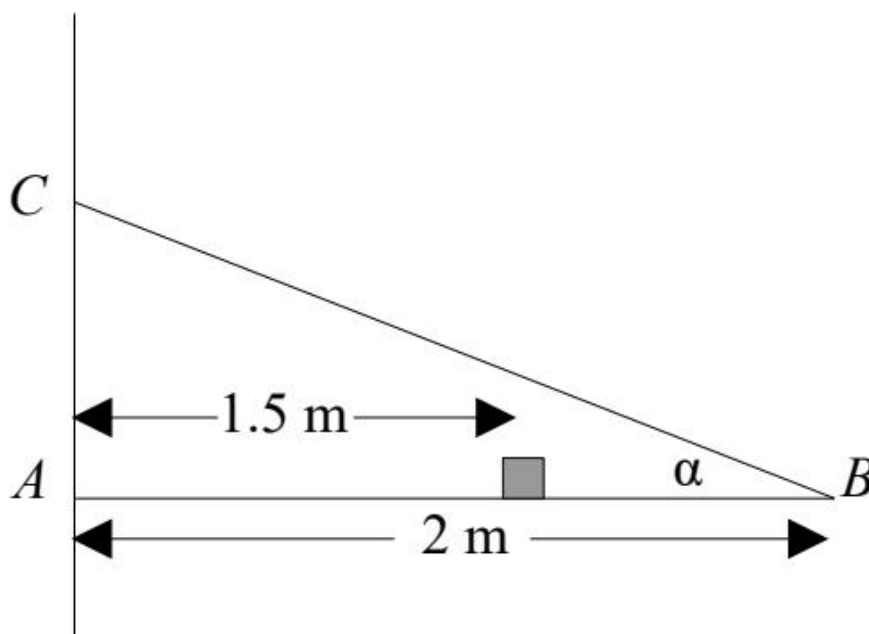


Given the rod is on the point of slipping.

Find the coefficient of friction between the rod and the ground.

(Total for question 3 is 9 marks)

- 4 A plank, AB , of length 2 m and mass M kg, is at rest with A against a rough vertical wall. The plank is held in a horizontal position by a rope attached to B and to the vertical wall at the point C . A small block of mass $2M$ is placed on the plank at P where $AP = 1.5$ m. The angle between the rope and the plank is α , where $\tan \alpha = \frac{3}{4}$. The plank is modelled as a uniform rod, the block is modelled as a particle and the rope is modelled as a light inextensible string.



- (a) Find, in terms of M , the tension in the string BC .

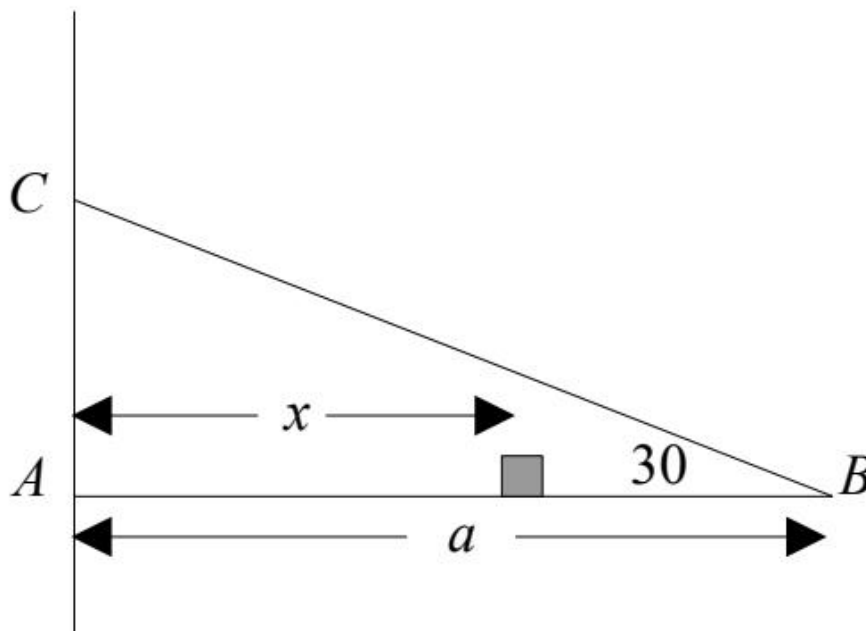
(3)

(b) Find the direction of the force exerted on the plank at A .

(5)

(Total for question 4 is 8 marks)

- 5 A plank, AB , of length a m and mass M kg, is at rest with A against a rough vertical wall. The plank is held in a horizontal position by a rope attached to B and to the vertical wall at the point C . The tension in the rope is $5Mg$. A small block of mass $3M$ is placed on the plank at P where $AP = x$. The angle between the rope and the plank is 30° , as shown in the diagram. The plank is modelled as a uniform rod, the block is modelled as a particle and the rope is modelled as a light inextensible string.



- (a) Find x in terms of a .

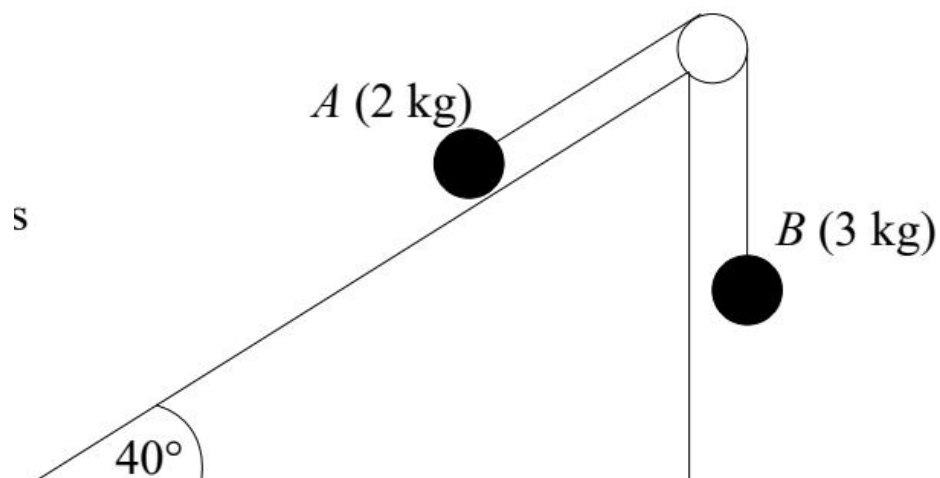
(4)

- (b) The force exerted on the plank at A by the wall acts in a direction which makes an angle θ with the horizontal. Find the value of $\tan \theta$.

(5)

(Total for question 5 is 9 marks)

- 6 Two particles A of mass 2 kg and B of mass 3 kg are connected by a light inextensible string. The string passes over a smooth pulley fixed at the top of a rough inclined plane. The plane is inclined at an angle of 40° to the horizontal. A lies at rest on the plane and B hangs freely from the edge of the plane with the string taut.



Particle A is released from rest and accelerates up the plane at 2 m s^{-2} .

- (a) The tension in the string

(3)

(b) The coefficient of friction between A and the plane

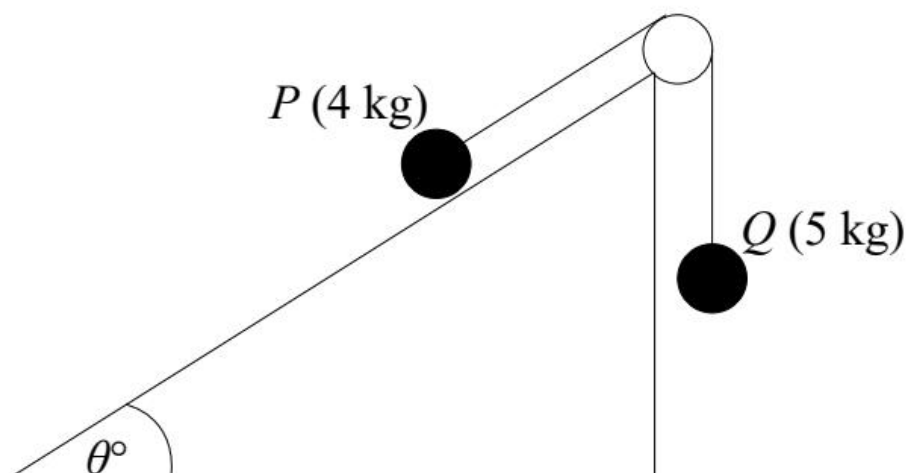
(3)

(c) The force exerted on the pulley by the string

(3)

(Total for question 6 is 9 marks)

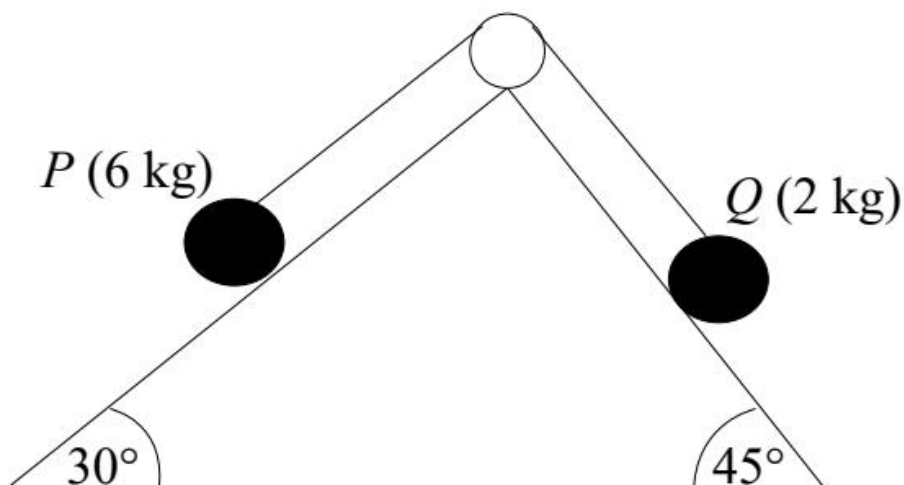
- 7 Two particles P of mass 4 kg and Q of mass 5 kg are connected by a light inextensible string. The string passes over a smooth pulley fixed at the top of a rough inclined plane. The coefficient of friction between the block and the plane is 0.2. The plane is inclined at an angle of θ° to the horizontal such that $\cos \theta = 0.8$. P lies at rest on the plane and Q hangs freely from the edge of the plane 2 m above the ground with the string taut.



The system is released from rest. Assuming Q hits the ground before P reaches the pulley. Find the speed at which Q hits the ground.

(Total for question 7 is 9 marks)

- 8 Two particles P of mass 6 kg and Q of mass 2 kg are connected by a light inextensible string. The string passes over a smooth pulley fixed at the top of a wedge. One face of the wedge is smooth and inclined at an angle of 30° to the horizontal. The other face of the wedge is rough and inclined at an angle of 45° to the horizontal. P lies on the smooth face and the string connecting the particles is taut. The coefficient of friction between Q and the rough face is 0.3.



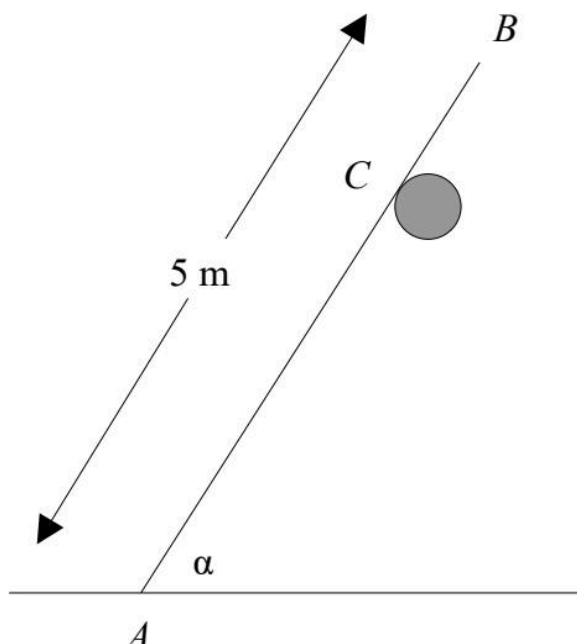
- (a) The tension in the string

(b) The acceleration of the system and the direction of travel.

(2)

(Total for question 8 is 9 marks)

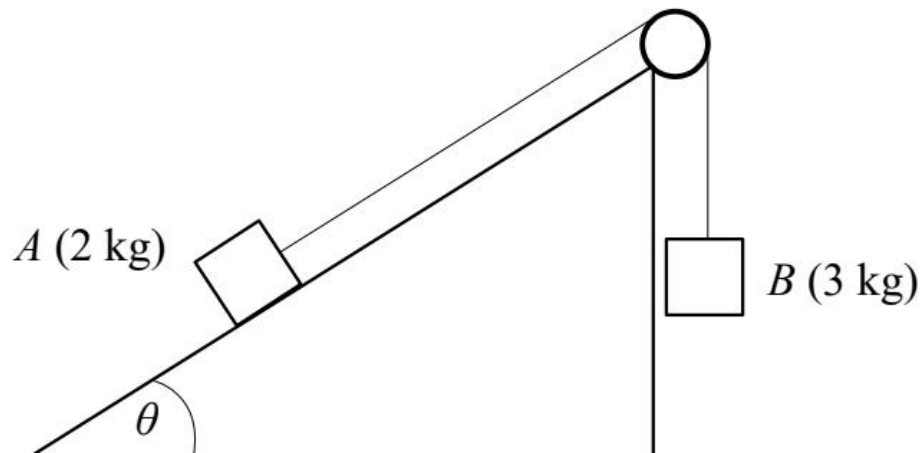
- 9 A ladder, AB , has length 5 m and mass 10 kg. The end of the ladder A is on rough horizontal ground. The ladder rests in limiting equilibrium against a fixed smooth horizontal rail at the point C , where $AC = 4$ m. The vertical plane containing AB is perpendicular to the rail. The ladder is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{12}{5}$. The ladder is modelled as a uniform rod. The coefficient of friction between the ladder and the ground is μ .



Using the model, find the value of μ .

(Total for question 9 is 8 marks)

- 10** Two blocks A of mass 2 kg and B of mass 3 kg are connected by a light string. Initially A is held at rest on a rough plane inclined at angle θ to the horizontal, where $\tan \theta = \frac{3}{4}$. The string passes over a smooth fixed pulley, with the string parallel to the line of greatest slope of the plane, as shown in the diagram. The coefficient of friction between A and the plane is $\frac{5}{8}$. The blocks are released and A moved up the plane. The string is modelled as inextensible and the blocks are modelled as particles.



- (a) Find the tension in the string.

- (b) After B reaches the ground, A continues to move up the plane until it comes to rest before it reaches the pulley. Determine whether A will remain at rest.

(2)

- (c) Suggest two refinements to the model that would make it more realistic.

(2)

(Total for question 10 is 11 marks)
