1.

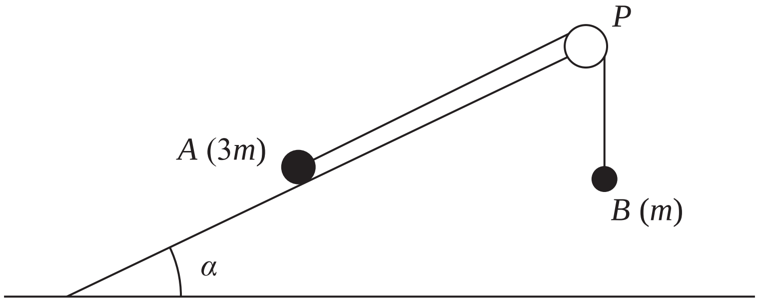


Figure 1

A small stone A of mass $3m$ is attached to one end of a string.

A small stone B of mass m is attached to the other end of the string.

Initially A is held at rest on a fixed rough plane.

The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$

The string passes over a pulley P that is fixed at the top of the plane.

The part of the string from A to P is parallel to a line of greatest slope of the plane.

Stone B hangs freely below P, as shown in Figure 1.

The coefficient of friction between A and the plane is $\frac{1}{6}$ $\mu = \frac{1}{6}$

Stone A is released from rest and begins to move down the plane.

The stones are modelled as particles.

The pulley is modelled as being small and smooth.

The string is modelled as being light and inextensible.

Using the model for the motion of the system before B reaches the pulley,

(a) write down an equation of motion for A

(2)

(b) show that the acceleration of A is $\frac{1}{10}g$

(7)

(c) sketch a velocity-time graph for the motion of B, from the instant when A is released from rest to the instant just before B reaches the pulley, explaining your answer.

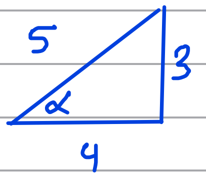
(2)

In reality, the string is not light.

(d) State how this would affect the working in part (b).

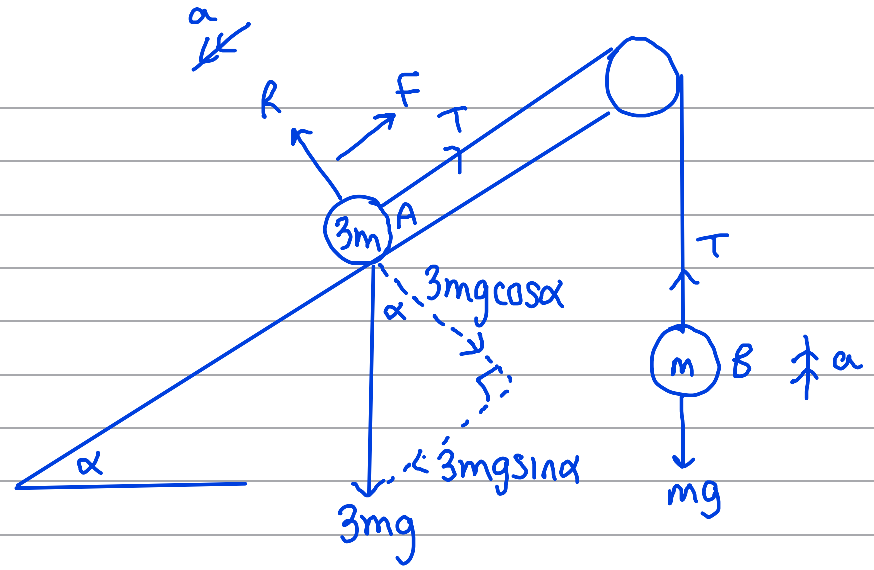
(1)

a) $\tan\alpha = 3/4$

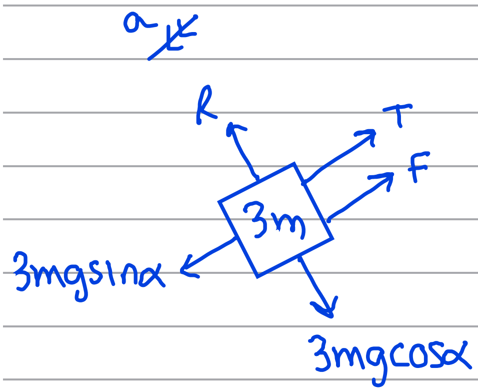


$\sin\alpha = 3/5$

$\cos\alpha = 4/5$



considering A:



1 1

$R(\swarrow)$: $3mg\sin\alpha - T - F = 3ma$

1

b) $R(\nwarrow)$ for A, forces balanced: $R = 3mg\cos\alpha$ 1

$= \frac{12mg}{5}$

$F = \mu R$, $\mu = \frac{1}{6}$

$\therefore F = \frac{1}{6} \times \frac{12mg}{5} = \frac{2}{5}mg$ 1

1

$R(\uparrow)$ for B: $T - mg = ma$ (1) 1

from (a), $3mg\sin\alpha - T - F = 3ma$

$\frac{9mg}{5} - T - \frac{2mg}{5} = 3ma$

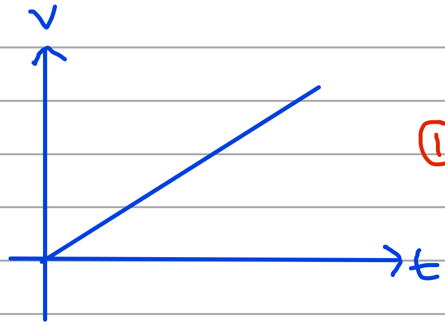
$\frac{7mg}{5} - T = 3ma$ (2)

① + ②: $\frac{7mg}{5} - mg = 3ma + ma$ ①

$\frac{2}{5}mg = 4ma$

$a = \frac{1}{10}g$ as required ①

c)



①

Since $a = \frac{g}{10}$, B moves with constant acceleration, and starts from rest. ①

d) the tensions in the two equations of motion would be different ①

2.

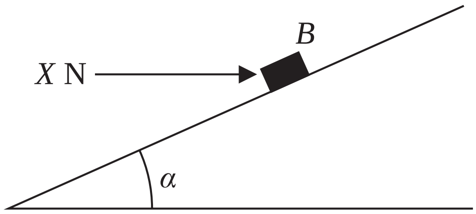


Figure 1

A rough plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$

A small block B of mass 5 kg is held in equilibrium on the plane by a horizontal force of magnitude X newtons, as shown in Figure 1.

The force acts in a vertical plane which contains a line of greatest slope of the inclined plane.

The block B is modelled as a particle.

The magnitude of the normal reaction of the plane on B is 68.6 N.

Using the model,

(a) (i) find the magnitude of the frictional force acting on B,

(3)

(ii) state the direction of the frictional force acting on B.

(1)

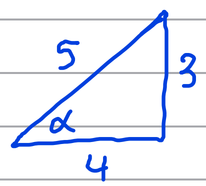
The horizontal force of magnitude X newtons is now removed and B moves down the plane.

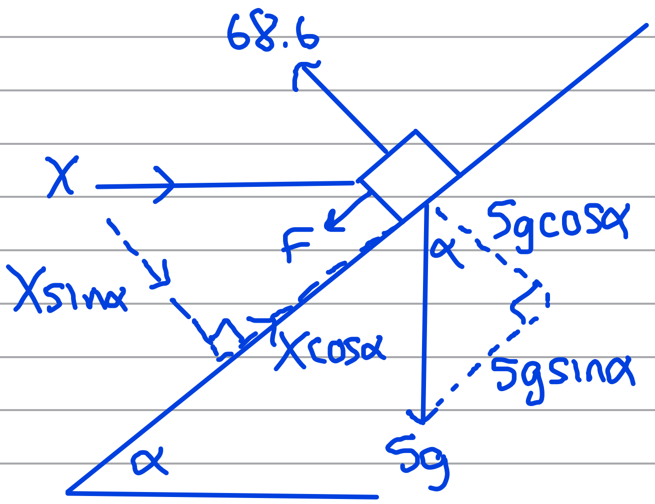
Given that the coefficient of friction between B and the plane is 0.5

(b) find the acceleration of B down the plane.

(6)

$\tan\alpha = 3/4$

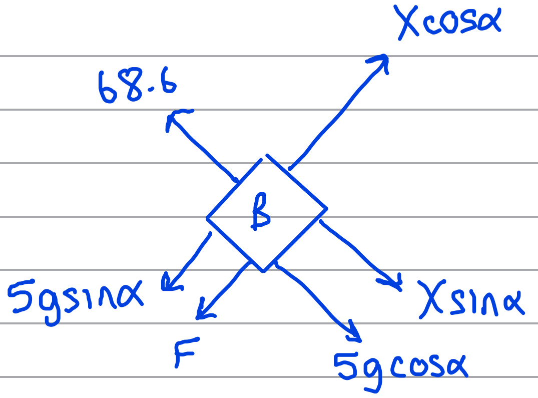




$\sin\alpha = 3/5$

$\cos\alpha = 4/5$

Question 2 continued



"R( )" means resolve

a)

(i) R(↖): $68.6 = X\sin\alpha + 5g\cos\alpha$ ①

$$\Rightarrow X = \frac{68.6 - 5g\cos\alpha}{\sin\alpha} = 49\text{ N}$$ ①

R(↗): $X\cos\alpha = 5g\sin\alpha + F$

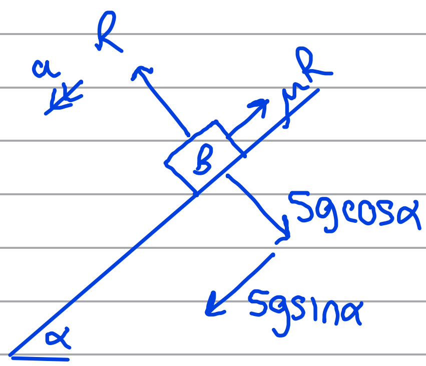
$$\Rightarrow F = X\cos\alpha - 5g\sin\alpha = 9.8\text{ N}$$ ①

(ii) Down the plane ①

Friction opposes motion; without friction the box would slide up the plane, so friction must act down to counteract this.

b) $\mu = 0.5$

$F = \mu R$
$= 0.5R$ ①



- R changes as X is removed
- friction now acts up the plane

R(↖): $R = 5g\cos\alpha = 39.2$ ① ①

R(↙): $5g\sin\alpha - \mu R = 5a$ ① ①

$$\therefore a = \frac{5g\sin\alpha - \mu R}{5}$$

$a = 1.96\text{ ms}^{-2}$ (3sf) ①