Cambridge International AS & A Level

Mathematics 9709/42

Paper 4 Mechanics October/November 2024

Question No(7)

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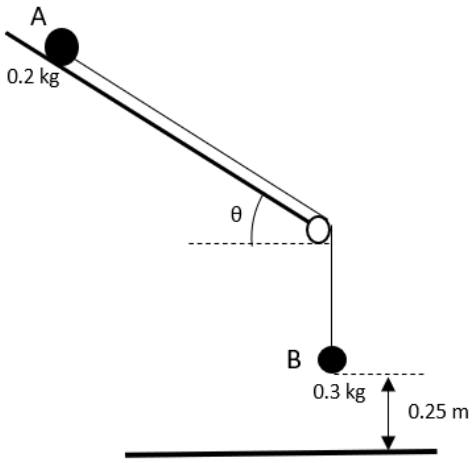


Two particles, A and B, of masses 0.2 kg and 0.3 kg respectively, are attached to the ends of a light inextensible string. The string passes over a small fixed smooth pulley which is attached to the bottom of a rough plane inclined at an angle θ to the horizontal where $\sin\theta = 0.6$. Particle A lies on the plane, and particle B hangs vertically below the pulley, 0.25 m above horizontal ground. The string between A and the pulley is parallel to a line of greatest slope of the plane (see diagram). The coefficient of friction between A and the plane is 1.125 . Particle A is released from rest.

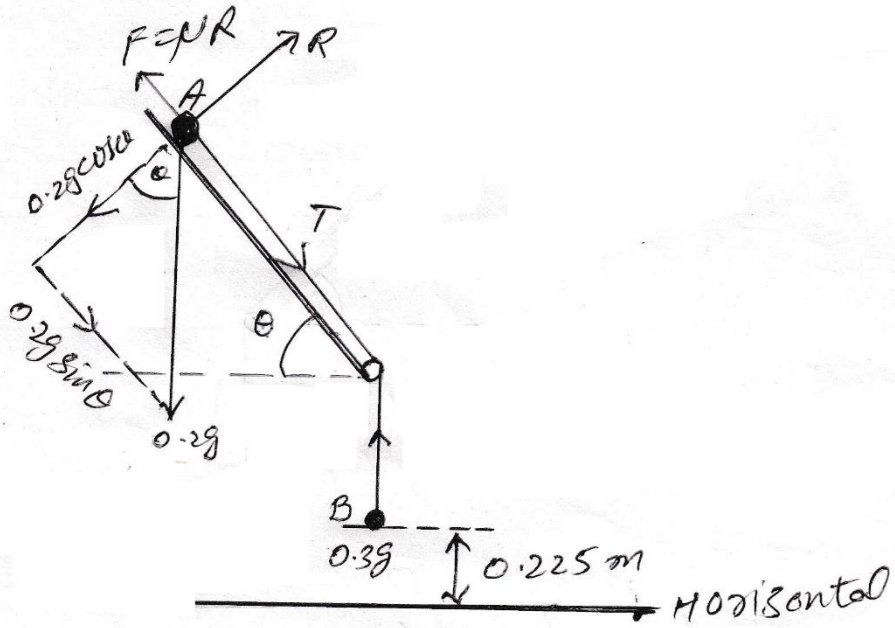
(a) Find the tension in the string and the magnitude of the acceleration of the particles.

(b) When B reaches the ground, it comes to rest.

Find the total distance that A travels down the plane from when it is released until it comes to rest. You may assume that A does not reach the pulley.

Solution:

(a)



Resolve the forces perpendicular to plane at A

As $\sin\theta = 0.6$

$\theta = \sin^{-1}(0.6)$

$= 0.6435$

$\cos 0.6435 = 0.8000$

$R = 0.2g\cos\theta$

$= 0.2(9.8)(0.8000)$

$R = 1.568$

As $F = \mu R$

$= (1.125)(1.568)$ $\quad \because \mu = 1.125$

$F = 1.764$

along the inclined plane

Net forces $= ma$

$T + 0.2g\sin\theta - F = 0.2a$

$T + (0.2)g(0.6) - F = 0.2a$

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$T + 1.176 - 1.764 = 0.2a$

$T - 0.588 = 0.2 \rightarrow (1)$

At particle B, resolve the forces vertically

$0.3g - T = 0.3a \rightarrow (2)$

Adding (1) & (2)

$0.3g - T = 0.3a$

$T - 0.588 = 0.2a$

$0.3g - 0.588 = 0.5a$

$2.94 - 0.588 = 0.5a$

$a = \frac{2.352}{0.5}$

$a = 4.7 \ m/s^2$

put $a = 4.7$ in (1)

$T - 0.588 = 0.2(4.7)$

$T = 0.588 + 0.2(4.7)$

$T = 1.53 \ N$

(b)

The acceleration is same for particles A and B, when particle B moves to ground.

For particle B, given data

Initial velocity, $u = 0$

$s = 0.25$

$a = 4.7$ (from part (a))

using

$$v^2 = u^2 + 2as$$

$$v^2 = (0)^2 + 2(4.7)(0.25)$$

$$v^2 = 2.4$$

when the particle B hit the ground then string become slack and tension become zero.

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Apply the Newton second law on A at the time of slack.

net force at A = 0.2a

$0.2g \sin\theta - \mu R = 0.2a$

$0.2g \sin\theta - (1.125)(1.568) = 0.2a$, R = 1.568 from Part (a)

$0.2g(0.6) - 1.764 = 0.2a$

$a = \dfrac{1.176 - 1.764}{0.2}$

$a = -3\ m/s^2$

Now using the Equation of motion

$v^2 = u^2 + 2as$

(Final velocity of B become the initial velocity of A when hitting ground or at the time of slack and final velocity of A becomes 0)

$(0)^2 = 2.4 + 2(-3)s$

$s = \dfrac{2.4}{6} = 0.4$

Total distance covered by A is

= distance by A (when B moves to ground) + distance by A, at slack time

= 0.25 + 0.4

S = 0.65 m