Horizontal & Vertical String – Exam Style Questions SOLUTIONS

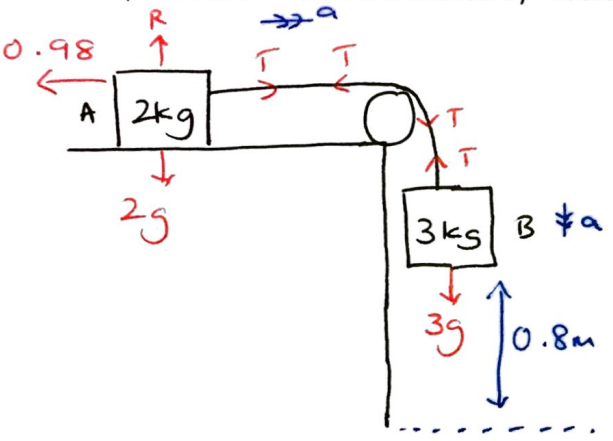
1. Two particles A and B of masses 2 kg and 3 kg respectively are connected by a light inextensible string passing over a small smooth pulley. Particle A lies on a rough horizontal table and experiences a frictional force 0.98 N. Particle B hangs freely, with the string taut, and is 0.8 m above the horizontal ground. The system is released from rest. Find:

a) the acceleration of the system **(3 marks)**

b) the tension in the string **(3 marks)**

c) the speed of B as it hits the ground **(2 marks)**

d) the total distance travelled by A before it comes to rest. **(5 marks)**



a, Consider A only, (→)

Using $F = ma$

$T - 0.98 = 2a$ — ①

Consider B only, (↓)

Using $F = ma$

$3g - T = 3a$ — ②

Adding ① & ②

$\Rightarrow 3g - 0.98 = 5a$

$28.42 = 5a$

$a = \frac{2}{5}g$

$= 5.684\,ms^{-2}$

b, Sub $a = 3.92$ in ①

$\Rightarrow T - 0.98 = 2(5.684)$

$T = 12.3$ N (3 S.F)

c) Consider B only

(↓) $s = 0.8$
$u = 0$ ← released from rest
$v = ?$
$a = 5.684$
t

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

$= 0 + 2(5.684)(0.8)$

$v = \sqrt{9.0944}$

$= 3.015.....$

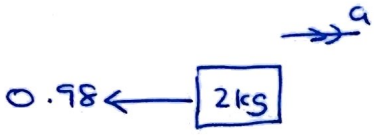
$= 3.0\ ms^{-1}$ (2 S.F)

d) When B hits the ground ⇒ string becomes slack

⇒ NO TENSION

⇒ WE NEED TO FIND NEW 'A'

Consider A only



Using $F = ma$ (→)

$-0.98 = 2a$

$a = -0.49\ ms^{-2}$

Finding the distance travelled by A when it comes to rest

⇒ Using $v^2 = u^2 + 2as$

$0 = (\sqrt{9.0944})^2 + 2(-0.49)s$

$s = 9.28\ m$

[For A $s = ?$
u = speed of B = $\sqrt{9.09...}$
$v = 0$ ($v = 0$)
a = new acc^n = -0.49
t]

When B strikes the ground, it has travelled a distance of 0.8 m

⇒ A would also travel a distance of 0.8 m

∴ Total distance travelled by A $= 0.8 + 9.28$

$= 10.1\ m$ (3 S.F)

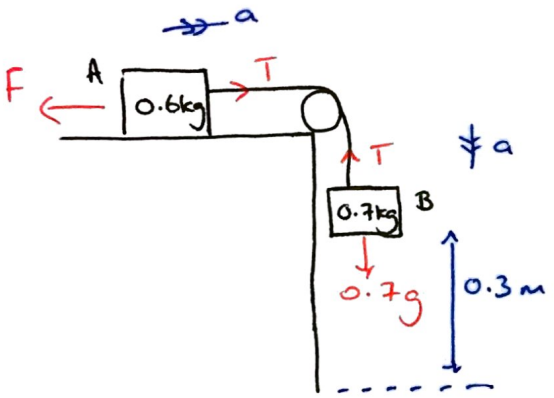
2. A block A of mass 600 g (0.6kg) rests on a rough horizontal table and is connected by a light inextensible string passing over a smooth pulley fixed at the edge of the table. The other end of the string is attached to a ball of mass 700 g (0.7kg) which hangs freely below the pulley. Block A experiences a resistance force of constant magnitude *F* N. The system is released from rest with the string taut. After release, B descends a distance of 0.3 m in 0.4 s. By writing down separate equations of motion A and B, calculate:

a) the tension in the string **(4 marks)**

b) the value of *F* **(3 marks)**

Assuming that B does not rebound when it hits the ground,

(c) find the total distance travelled by A before it comes to rest. **(6 marks)**



a) Finding acc^n of system

For B

$s = 0.3$
$u = 0$
v
$a = ?$
$t = 0.4$

Using $s = ut + \frac{1}{2}at^2$

$0.3 = 0 + \frac{1}{2}a(0.4)^2$

$a = 3.75\ ms^{-2}$

b, Consider B only

$(\downarrow)\ F = ma$

$0.7g - T = 0.7(3.75)$

$T = 4.235\ N$

$T = 4.2\ N$ (2 s.f)

c, Consider A

$(\rightarrow)\ F = ma$

$T - F = 0.6 \times 3.75$

$4.235 - F = 2.25$

$F = 1.985\ N$

c) Finding the speed of B as it hits the ground

$\Rightarrow$ (↓) Consider B

$s = 0.3$
$u = 0$
$v = ?$
$a = 3.75$
$t =$

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

$v^2 = 0 + 2(3.75)(0.3)$

$v = \sqrt{2.25}$

$v = 1.5 \text{ ms}^{-1}$

When B hits the ground, string becomes slack

$\Rightarrow$ NO TENSION

$\Rightarrow$ NEED TO FIND NEW 'A'

Finding new acceleration (acc^n of A)

$\Rightarrow$ Consider A

(→) Using $F = ma$

$-1.985 = 0.6a$

$a = -\frac{397}{120} \text{ ms}^{-2}$

Finding the distance when A comes to rest

$\Rightarrow$ $s = ?$
$u =$ speed of B $= 1.5$
$v = 0$
$a =$ new acc^n $= -\frac{397}{120}$
t

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

$0 = (1.5)^2 + 2\left(-\frac{397}{120}\right)s$

$s = 0.340\ldots\ldots$

When B hits the ground, it travels a distance 0.3m

$\Rightarrow$ A would also travel 0.3 m

$\therefore$ Total distance travelled by A $= 0.3 + 0.340\ldots$

$= 0.640\ldots$

$= 0.64$ (2 s.f)