Additional Assessment Materials

Summer 2021

Pearson Edexcel GCE in Mathematics

8MA0_22 (Public release version)

Resource Set 1: Topic 8

Forces and newton laws

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an optional part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

1.

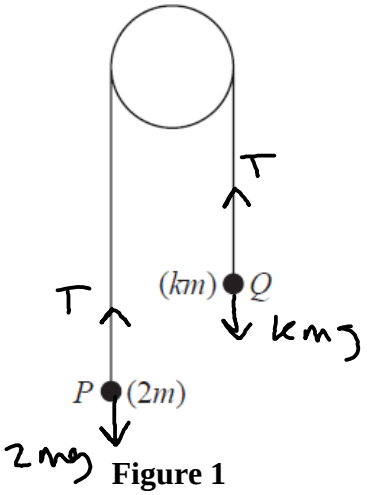

Figure 1

Two small balls, P and Q, have masses $2m$ and km respectively, where $k < 2$.

The balls are attached to the ends of a string that passes over a fixed pulley.

The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1.

The system is released from rest and, in the subsequent motion, P moves downwards with an acceleration of magnitude $\frac{5g}{7}$.

The balls are modelled as particles moving freely.
The string is modelled as being light and inextensible.
The pulley is modelled as being small and smooth.

Using the model,

(a) find, in terms of m and g, the tension in the string,

(3)

$F = ma$ $\quad 2mg - T = 2m(5g/7)$

$2mg - 10/7\,mg = T \rightarrow T = 4/7\,mg$

(b) explain why the acceleration of Q also has magnitude $\frac{5g}{7}$,

(1)

String modelled as inextensible

(c) find the value of k.

(4)

$F = ma$ $\quad T - kmg = kma$

$4/7\,mg - kmg = km(5g/7) \rightarrow (4/7 - k)mg = mg(5/7\,k)$

$4/7 - k = 5/7\,k$

$4/7 = 12/7\,k$

$k = 4/12 = 1/3$

(d) Identify one limitation of the model that will affect the accuracy of your answer to part (c).

(1)

Pulley may not be smooth

(Total for Question 1 is 9 marks)

2.

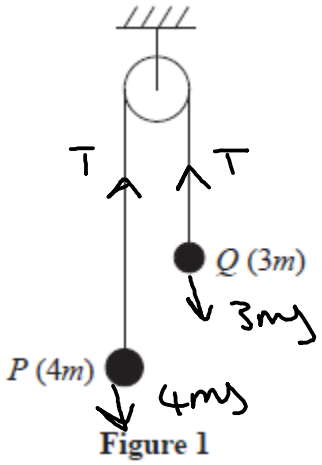

Figure 1

One end of a string is attached to a small ball P of mass $4m$.

The other end of the string is attached to another small ball Q of mass $3m$.

The string passes over a fixed pulley.

Ball *P* is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1.

Ball *P* is released.

The string is modelled as being light and inextensible, the balls are modelled as particles, the pulley is modelled as being smooth and air resistance is ignored.

(*a*) Using the model, find, in terms of *m* and *g*, the magnitude of the force exerted on the pulley by the string while *P* is falling and before *Q* hits the pulley.

(8)

① $4mg - T = 4ma$

② $T - 3mg = 3ma$

$T = 3ma + 3mg$

$4mg - 3ma - 3mg = 4ma$

$mg = 7ma$

$ma = \frac{mg}{7}$

$T = 3\left(\frac{mg}{7}\right) + 3mg$

$T = mg\left(3 + \frac{3}{7}\right)$

$T = \frac{24}{7}mg$

Total force exerted on pulley $= F = 2T = \frac{48}{7}mg$ N

(*b*) State one limitation of the model, apart from ignoring air resistance, that will affect the accuracy of your answer to part (a).

(1)

Pulley may not be light

(Total for Question 2 is 9 marks)

3. A bird leaves its nest at time $t = 0$ for a short flight along a straight line.

The bird then returns to its nest.

The bird is modelled as a particle moving in a straight horizontal line.

The distance, s metres, of the bird from its nest at time t seconds is given by

$$s = \tfrac{1}{10}(t^4 - 20t^3 + 100t^2), \text{ where } 0 \leq t \leq 10.$$

(*a*) Explain the restriction $0 \leq t \leq 10$

(3)

Substitute $t = 0$ in equation $\rightarrow s = 0$

Substitute $t = 10$ in equation $\rightarrow s = 1/10(0) = 0$

So $s = 0$ for both when $t = 0$ and 10

$s = 1/10(t^4 - 20t^3 + 100t^2) \rightarrow 1/10t^2(t^2 - 20t + 100)$

$= 1/10t^2(t - 10)^2$

So $s > 0$ for $0 < t < 10$

(*b*) Find the distance of the bird from the nest when the bird first comes to instantaneous rest.

(6)

Bird at rest when $v = 0$ $\quad v = \frac{ds}{dt}$

$ds/dt \rightarrow 1/10(4t^3 - 60t^2 + 200t) = v$

make $v = 0$ and solve for t.

$1/10(4t^3 - 60t^2 + 200t) = 0$

$t^3 - 15t^2 + 50t = 0 \longrightarrow t(t^2 - 15t + 50) = 0$

$(t-5)(t-10) = 0$

Therefore $t = 0, 5$ and 10

(Total for Question 3 is 9 marks)

4.

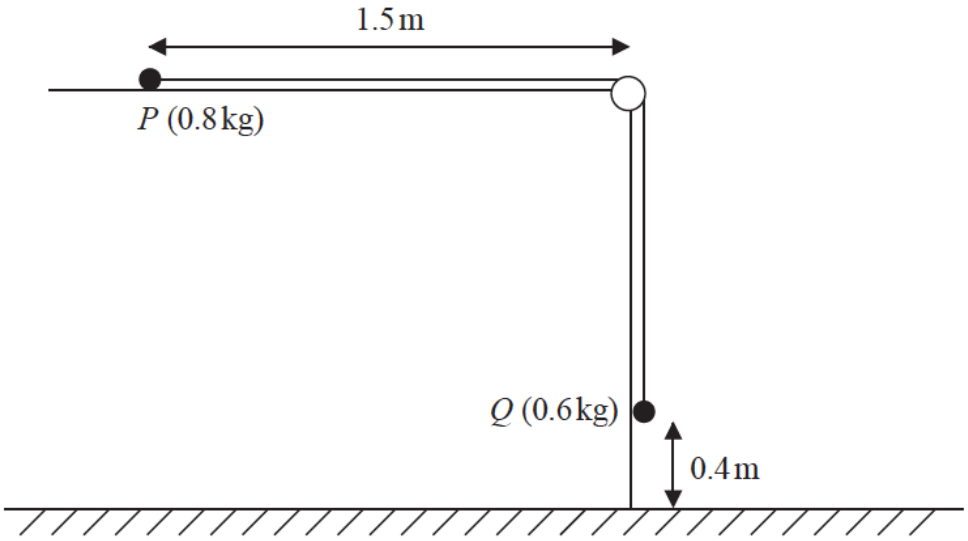

Figure 1

A small ball, *P*, of mass 0.8 kg, is held at rest on a smooth horizontal table and is attached to one end of a thin rope.

The rope passes over a pulley that is fixed at the edge of the table.

The other end of the rope is attached to another small ball, *Q*, of mass 0.6 kg, that hangs freely below the pulley.

Ball *P* is released from rest, with the rope taut, with *P* at a distance of 1.5 m from the pulley and with *Q* at a height of 0.4 m above the horizontal floor, as shown in Figure 1.

Ball *Q* descends, hits the floor and does not rebound.

The balls are modelled as particles, the rope as a light and inextensible string and the pulley as small and smooth.

Using this model,

(*a*) show that the acceleration of *Q*, as it falls, is 4.2 m s^{-2}

(5)

(1) $0.6g - T = 0.6a$ (2) $T = 0.8a$

$0.6g - 0.8a = 0.6a \longrightarrow 0.6g = 1.4a$

$a = \frac{0.6g}{1.4} = 4.2\,ms^{-2}$

(*b*) find the time taken by *P* to hit the pulley from the instant when *P* is released.

(6)

$s = ut + 1/2\,at^2$

$s = 0.4$
$u = 0$
$v = ?$
$a = 4.2$
$T = ?$

Time taken for Q to hit floor

$0.4 = 1/2 \times 4.2 \times t$

$t = \frac{0.4}{2.1} = 0.436$ seconds

Time for P to hit pulley after Q hits floor

$v = u + at \rightarrow v = 0 + 4.2 \times 0.436 = 1.8312\,ms^{-1}$

$t = \frac{1.5 - 0.4}{1.8312}$

Total time $= 0.436 + \frac{1.5 - 0.4}{1.8312}$

$= 1.04$ seconds

(*c*) State one limitation of the model that will affect the accuracy of your answer to part (*a*).

(1)

Rope is inextensible

(Total for Question 4 is 12 marks)