Additional Assessment Materials

Summer 2021

Pearson Edexcel GCE AS Physics

Topic 2: Mechanics

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(Public release version)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

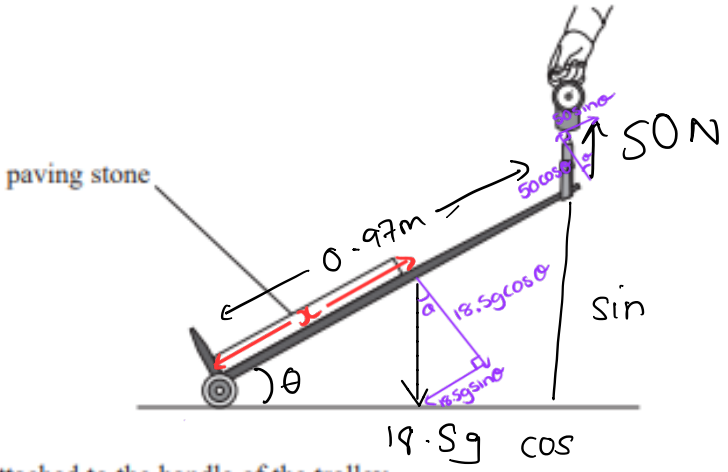
- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional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- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.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

13 A gardener used a trolley to move a paving stone.



A force meter was attached to the handle of the trolley.

The gardener recorded the following measurements when the trolley was at rest in the position shown in the diagram.

mass of trolley and paving stone = 18.5 kg

length of trolley = 97 cm

force on handle = 50 N

(a) Determine the distance of the centre of gravity of the loaded trolley from the wheels.

(3)

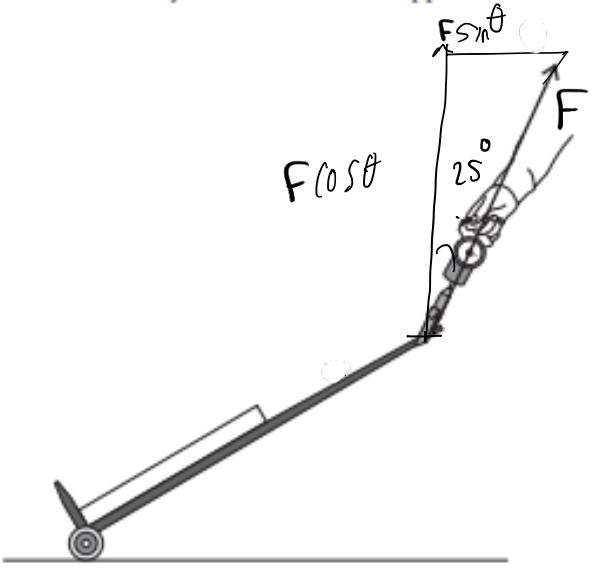
moments at base ↺ = $50 \times 0.97\cos\theta = 18.5 \times 9.81 \times \cos\theta \times x$

$x = \frac{50 \times 0.97}{18.5 \times 9.81} = 0.267289716$

≈ 0.27 (2sf)

Distance = 0.27m

(b) The gardener then pulled the trolley and measured the applied force while the trolley was moving.



The direction of the applied force is 25° to the vertical, as shown by the arrow.

(i) Calculate the magnitude of the applied force.

Assume the magnitude of the vertical component of the force remains at 50 N.

(2)

$F\cos\theta = 50$

$F\cos 25 = 50$

$F = \frac{50}{\cos 25} = 55.168895\ldots \approx 55\ (2sf)$

Magnitude of applied force = 55 N

(ii) The gardener continues to walk and pulls the trolley a distance of 15 m in a time of 4.2 s.

Calculate the power developed while pulling the trolley.

(3)

$P = \frac{W}{t} = \frac{Fd}{t} = \frac{(55\sin 25)(15)}{4.2} = 83.014301\ldots \approx 83\ W\ (2sf)$

Power = 83 W

(Total for Question 13 = 8 marks)

13 Road trains are used in Australia to transport freight across large, flat areas of the country. They consist of a minimum of three trailers connected to a cab unit to pull them along.

(a) The braking distance of a road train travelling at 15 m s^{-1} is 70 m.

Assuming that the same braking force is applied at all speeds, show that the braking distance of a road train when travelling at 25 m s^{-1} is about 190 m.

(3)

$s = \frac{d}{t} \rightarrow t = \frac{d}{s} = \frac{70}{15} = \frac{14}{3}$ s

$\therefore s \quad 15 : 25 \longrightarrow St = d$

$1 : 5/3$

$25 \times \frac{70}{9} = 194.4\ldots$

$\therefore t \quad \frac{14}{3} : \frac{70}{9} \approx 190$ m (2sf)

(b) A car accelerates uniformly at 3.7 m s^{-2} as it passes a stationary road train.

The initial speed of the car is 30 m s^{-1} and it reaches the speed limit of 130 km h^{-1} as it passes the front of the cab.

Calculate the length of the road train.

(3)

$s = ?$

$u = 30$

$v = 130 \text{ km/h} = \frac{325}{9} \text{ ms}^{-1}$

$a = 3.7$

t

$v^2 = u^2 + 2as \Rightarrow \frac{v^2 - u^2}{2a} = s$

$\frac{\left(\frac{325}{9}\right)^2 - 30^2}{2 \times 3.7} = s$

$s = 54.896\,2793$

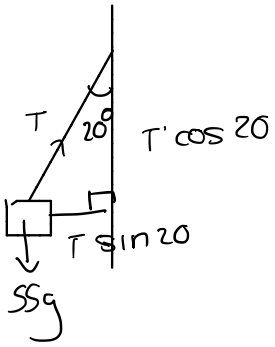
≈ 55 m (2sf)

Length of the road train = 55 m

$v = 130 \text{ km/h} \times \frac{1000}{3600}$

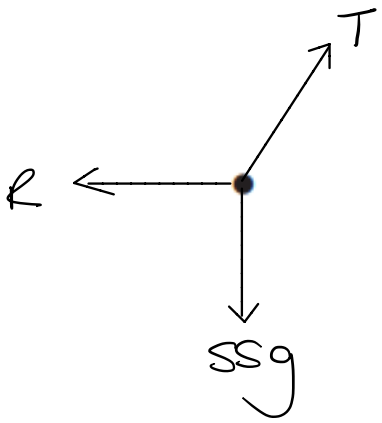
$= \frac{325}{9} \text{ ms}^{-1}$

16 The diagram shows a rock climber of mass 55 kg. She is hanging on a rope with one foot in contact with a rock face. She uses this foot to push herself horizontally away from the rock face. The rope is inclined at 20° to the vertical.



(a) Complete the free-body force diagram below to represent the forces acting on the climber.

(3)



(b) (i) Show that the tension in the rope is about 600 N.

(3)

$T\cos 20 = 55g$

$T = \frac{55g}{\cos 20}$

$T = 574.177\ldots = 570\ \text{N}\ (3\text{sf})$

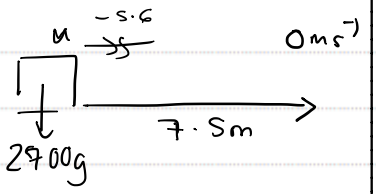
$\approx 600\ \text{N}\ (1\text{sf})$

9 A vehicle that skids can leave a mark on the road surface. This skid mark can be used to calculate the velocity of the vehicle at the start of the skid.

At a test track a car of mass 1500 kg was collided into the back of a stationary car of mass 1200 kg. The two cars skidded along the road together, leaving skid marks of length 7.5 m. The cars decelerated at 5.6 m s^{-2} to a stop at the end of the skid.

(a) Show that the velocity of the two cars at the start of the skid was about 9 m s^{-1}.

(3)



$v^2 = u^2 + 2as \Rightarrow u^2 = v^2 - 2as$

$5.6(2)(7.5) = u^2$

$u = 9.165151889 \approx 9\ ms^{-1}$

(b) Calculate the velocity with which the car of mass 1500 kg collided with the stationary car.

(3)

$1500u = 2700(9)$ → momentum before = momentum after

$1500u = 24300$

$u = 16.2\ m/s$

Velocity = 16 (2sf) ms^{-1}

(c) In practice, the velocity of the car is not exactly the same as that calculated in (b).

Explain why.

(2)

As energy will be lost due to friction between the cars and the road and energy will be transferred to the surroundings, meaning kinetic energy in reality is less than calculate so velocity is also less.

(Total for Question 9 = 8 marks)

OR

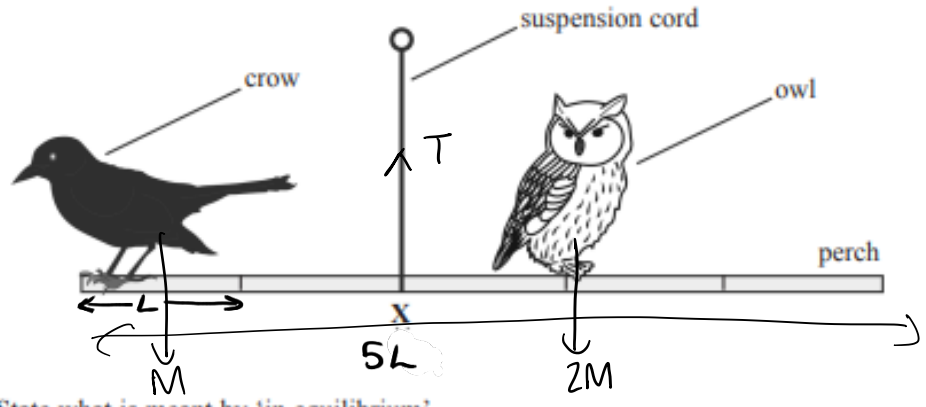
c) • Some kinetic energy will be transferred into thermal energy, due to friction

• $KE = \frac{1}{2}mv^2$

$KE \propto v^2$

∴ If KE decreases, velocity will also decrease

10 In a 'balancing birds' puzzle, model owls and crows are each placed in one of six equally spaced positions marked on a perch. The perch has negligible mass, and is suspended from another of the six marked positions. With the birds placed, and the perch suspended, as shown, the puzzle is in equilibrium.



(a) State what is meant by 'in equilibrium'.

(2)

when the resultant force is zero and the puzzle is stationary.

Anticlockwise moments = clockwise moments

(b) (i) The owl has a mass $2M$ and the crow has a mass M. Show that the perch will balance when suspended as shown from position X.

(1)

$T = 3M$, $2L = X$

moments at crow) $3L(2M) = 2L(3M)$

$6LM = 6LM$

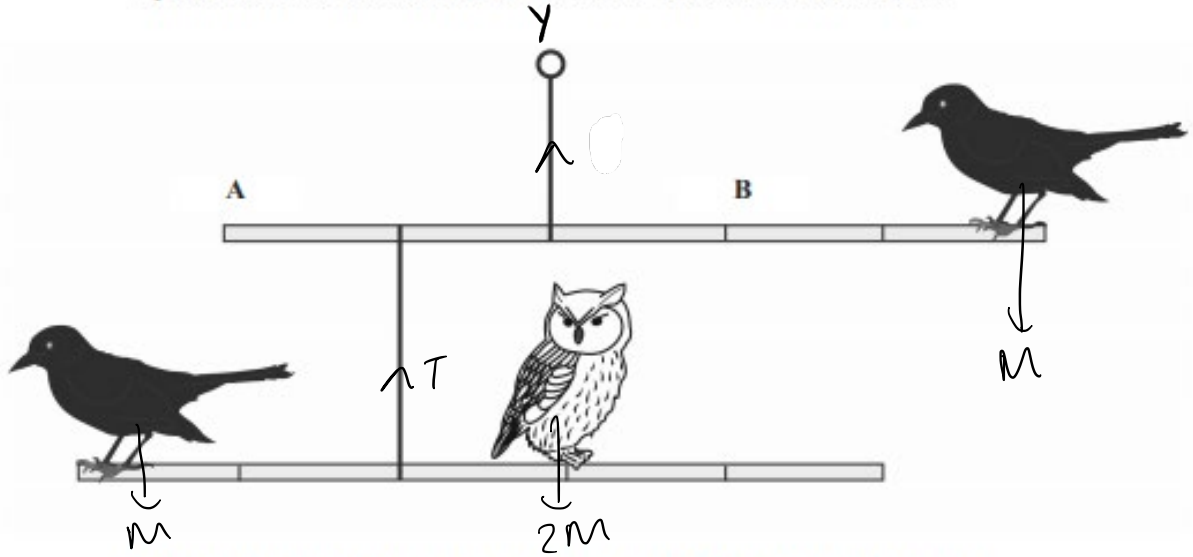
$0 = 0$

∴ in equilibrium when suspended from X.

Anticlockwise moments = clockwise moments

∴ at X, the puzzle is at equilibrium.

(ii) The perch is then attached to a second perch and suspended as shown. Two more birds, not shown, are placed at A and B, and the whole arrangement is in equilibrium. Each crow has the same mass M. The mass of an owl is $2M$.



Explain, with the aid of a calculation, which type of bird sits at A and which type of bird sits at B to ensure the whole arrangement is in equilibrium.

(3)

Anticlockwise moments = clockwise moments

moments about Y:

(CW) $(L \times B) + (3L \times M)$

(ACW) $(L \times T) + (2L \times A)$

$LB + 3LM = LT + 2LA$

$L(B + 3M) = L(T + 2A)$

$B + 3M = 3M + 2A$ (as $T = 3M$)

$B = 2A$

(Total for Question 10 = 6 marks)

so let $A = M$, then $B = 2M$

∴ a crow should be at A and an owl at B

Checking –

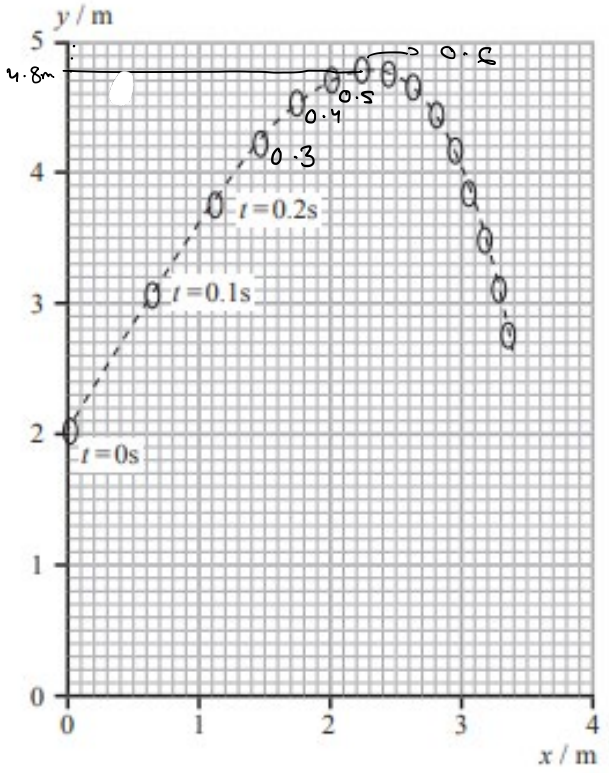
$B + 3M = T + 2A$

$2M + 3M = 3M + 2M$

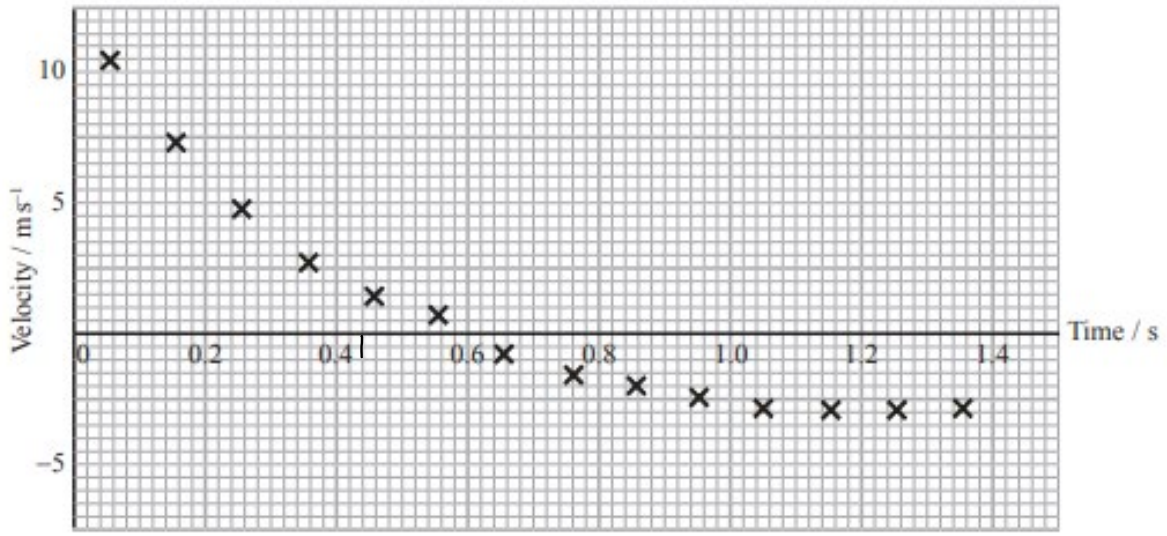
$5M = 5M$

∴ $B = 2M$, $A = M$

16 In a game of badminton, a shuttlecock is hit by a racket. The graph shows how the vertical displacement (y) and horizontal displacement (x) of the shuttlecock vary from the moment it leaves the racket. The positions are recorded every 0.10 s.



(a) The graph below shows how the velocity of the shuttlecock in the vertical direction varies with time.



(i) Explain how the velocities have been calculated from the successive vertical positions of the shuttlecock.

(2)

The shuttlecock starts at a position 2m high, you can use the graph to calculate the change in distance and divide by time to get speed → speed = distance / time

(ii) State why these velocities have been plotted at the mid-range of the time interval.

(1)

So you find the average time from that time interval

(iii) State, with a reason, two pieces of evidence from the graphs that show that the shuttlecock does **not** follow the motion of a projectile moving freely under gravity.

(3)

① The graph is not a straight line, so there isn't a constant gradient and ∴ there isn't a constant acceleration

② the graph does not start at 0

(iv) Show, using the velocity-time graph, that the maximum height gained by the shuttlecock is about 3 m.

(3)

at max height, $v = 0$ and ∴ $t = 0.6$

using the distance graph when $t = 0.6$

$y = 4.8$

$4.8 - 2 = 2.8\text{ m} \approx 3\text{ m}$

TOTAL FOR PAPER IS 43 MARKS