Please check the examination details below before entering your candidate information

Candidate surname	Other names
StemUp Model Solution	

Pearson Edexcel
International Advanced Level

Centre Number	Candidate Number

Thursday 14 May 2020

Afternoon (Time: 1 hour 30 minutes)	Paper Reference **WME01/01**

Mathematics

International Advanced Subsidiary/Advanced Level
Mechanics M1

You must have:	Total Marks
Mathematical Formulae and Statistical Tables (Blue), calculator	

Candidates may use any calculator permitted by Pearson regulations. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear.
  Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either 2 significant figures or 3 significant figures.

Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. The total mark for this paper is 75.
- The marks for each question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

Turn over ▶

P65760A

©2020 Pearson Education Ltd.

1/1/1/1/

P 6 5 7 6 0 A 0 1 3 2

Pearson

Leave blank

1. Two particles, P and Q, with masses m and $2m$ respectively, are moving in the same direction along the same straight line when they collide directly. Immediately before they collide, P is moving with speed $4u$ and Q is moving with speed u. Immediately after they collide, both particles are moving in the same direction and the speed of Q is four times the speed of P.

(a) Find the speed of Q immediately after the collision.

(3)

(b) Find the magnitude of the impulse exerted by Q on P in the collision.

(3)

(c) State clearly the direction of this impulse.

(1)

(a) Take the direction of motion as positive. Let P have speed v after.

Then Q has speed 4v after the collision.

CLM: $m \times 4u + 2m \times u = mv + 2m \times 4v$

$6mu = 9mv$

$v = \frac{2u}{3}$

Speed of Q $= 4v = \frac{8u}{3}$

(b) Impulse on P = change in momentum of P

$I = m(4u - \frac{2u}{3})$

Magnitude of impulse $= \frac{10mu}{3}$

(c) The impulse on P is opposite to the direction of motion (of P and Q).

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 1 continued

Q1

(Total 7 marks)

Leave blank

2. A small ball is thrown vertically upwards with speed 14.7 m s^{-1} from a point that is 19.6 m above horizontal ground. The ball is modelled as a particle moving freely under gravity.

Find

(a) the total time from when the ball is thrown to when it first hits the ground,

(4)

(b) the speed of the ball immediately before it first hits the ground,

(3)

(c) the total distance travelled by the ball from when it is thrown to when it first hits the ground.

(4)

(d) Sketch a velocity-time graph for the motion of the ball from when it is thrown to when it first hits the ground.

State the coordinates of the start point and the coordinates of the end point of your graph.

(3)

(a) Upwards positive: $u = 14.7$, $a = -9.8$, $s = -19.6$

$s = ut + \frac{1}{2}at^2$: $\quad -19.6 = 14.7t + \frac{1}{2}(-9.8)t^2$

$4.9t^2 - 14.7t - 19.6 = 0$

$t^2 - 3t - 4 = 0$

$(t - 4)(t + 1) = 0 \quad \Rightarrow \quad t = 4 \quad (t = -1 \text{ rejected})$

Total time = 4 s

(b) $v = u + at = 14.7 + (-9.8) \times 4 = -24.5$

Speed = 24.5 m s^{-1}

(c) At the highest point $v = 0$: $\quad v^2 = u^2 + 2as$

$0 = 14.7^2 + 2(-9.8)s$

$s = \frac{216.09}{19.6} = 11.025$ m above the point of projection

Total distance = $2 \times 11.025 + 19.6 = 41.65$

Total distance = 41.7 m (3 s.f.)

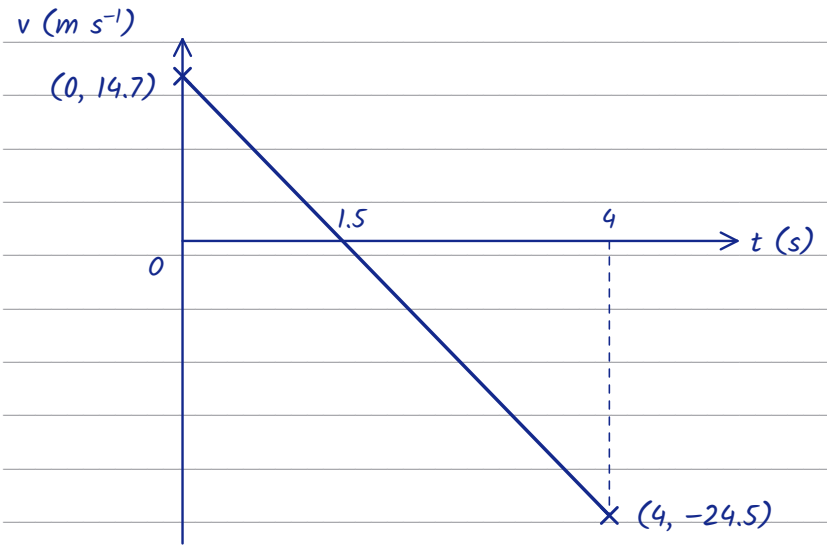
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 2 continued

(d) v-t graph (upwards positive):



Start point (0, 14.7), end point (4, −24.5)

Leave blank

Question 2 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 2 continued

(Total 14 marks)

Q2

Leave blank

3.

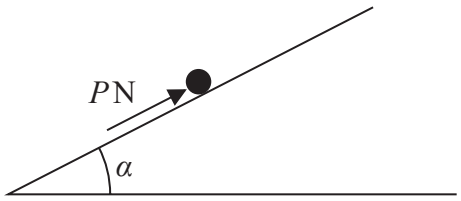


Figure 1

A particle of mass 10 kg is placed on a fixed rough inclined plane. The plane is inclined to the horizontal at an angle α, where $\tan\alpha = \frac{3}{4}$. The particle is held in equilibrium by a force of magnitude P newtons, which acts up the plane, as shown in Figure 1. The line of action of the force lies in a vertical plane that contains a line of greatest slope of the plane. The coefficient of friction between the particle and the plane is $\frac{1}{2}$.

(a) Find the normal reaction between the particle and the plane.

(2)

(b) Find the greatest possible value of P.

(4)

(c) Find the least possible value of P.

(2)

(a) $\tan\alpha = \frac{3}{4} \Rightarrow \sin\alpha = \frac{3}{5}, \quad \cos\alpha = \frac{4}{5}$

Resolving perpendicular to the plane:

$R = 10g\cos\alpha = 10 \times 9.8 \times 0.8 = 78.4$

Normal reaction = 78.4 N

(b) P greatest: particle about to slide up, friction acts down the plane.

$F = \mu R = 0.5 \times 78.4 = 39.2$ N

Resolving parallel to the plane:

$P = 10g\sin\alpha + F = 10 \times 9.8 \times 0.6 + 39.2$

$P = 58.8 + 39.2 = 98$

Greatest value of P = 98

(c) P least: particle about to slide down, friction acts up the plane.

$P = 10g\sin\alpha - F = 58.8 - 39.2 = 19.6$

Least value of P = 19.6

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 3 continued

Leave blank

Question 3 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 3 continued

Q3

(Total 8 marks)

Leave blank

4.

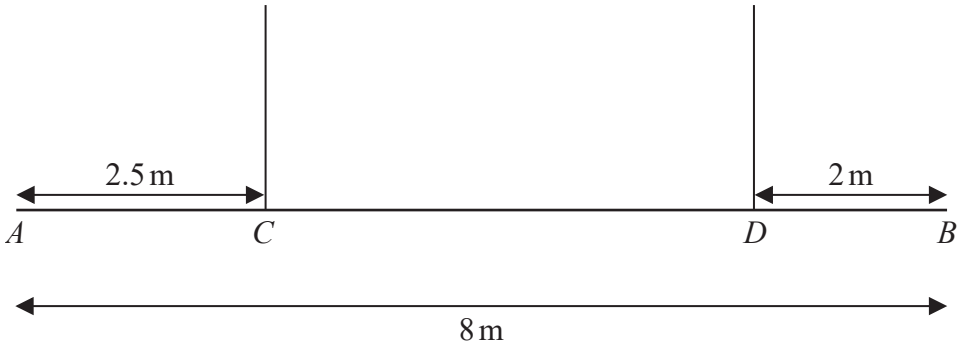


Figure 2

A non-uniform beam AB has length 8 m and mass M kg.

The centre of mass of the beam is d metres from A.

The beam is supported in equilibrium in a horizontal position by two vertical light ropes. One rope is attached to the beam at C, where $AC = 2.5$ m and the other rope is attached to the beam at D, where $DB = 2$ m, as shown in Figure 2.

A gymnast, of mass 64 kg, stands on the beam at the point X, where $AX = 1.875$ m, and the beam remains in equilibrium in a horizontal position but is now on the point of tilting about C.

The gymnast then dismounts from the beam.

A second gymnast, of mass 48 kg, now stands on the beam at the point Y, where $YB = 0.5$ m, and the beam remains in equilibrium in a horizontal position but is now on the point of tilting about D.

The beam is modelled as a non-uniform rod and the gymnasts are modelled as particles.

Find the value of M.

(8)

First gymnast at X: on the point of tilting about C, so the tension in the rope at D is zero ($T_D = 0$).

XC = 2.5 − 1.875 = 0.625 m. G is (d − 2.5) m from C.

M(C): $64g \times 0.625 = Mg(d - 2.5)$

$40 = M(d - 2.5)$ ... (1)

Second gymnast at Y: on the point of tilting about D, so the tension in the rope at C is zero ($T_C = 0$).

AD = 6 m, AY = 7.5 m, so DY = 1.5 m. G is (6 − d) m from D.

M(D): $48g \times 1.5 = Mg(6 - d)$

$72 = M(6 - d)$ ... (2)

(1) + (2): $112 = M(d - 2.5 + 6 - d) = 3.5M$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 4 continued

$M = \frac{112}{3.5} = 32$

$M = 32$

Leave blank

Question 4 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 4 continued

Q4

(Total 8 marks)

Leave blank

5. A particle P is moving in a plane with constant acceleration.
The velocity, $\mathbf{v}\,\text{m s}^{-1}$, of P at time t seconds is given by

$$\mathbf{v} = (7 - 5t)\mathbf{i} + (12t - 20)\mathbf{j}$$

(a) Find the speed of P when $t = 2$

(3)

(b) Find, to the nearest degree, the size of the angle between the direction of motion of P and the vector $\mathbf{j}$, when $t = 2$

(3)

The constant acceleration of P is $\mathbf{a}\,\text{m s}^{-2}$

(c) Find $\mathbf{a}$ in terms of $\mathbf{i}$ and $\mathbf{j}$

(3)

(d) Find the value of t when P is moving in the direction of the vector $(-5\mathbf{i} + 8\mathbf{j})$

(4)

(a) $t = 2$: $v = (7 - 10)i + (24 - 20)j = -3i + 4j$

Speed $= \sqrt{((-3)^2 + 4^2)} = \sqrt{25}$

Speed $= 5\ m\ s^{-1}$

(b) Angle θ between $v = -3i + 4j$ and j:

$\tan\theta = \frac{3}{4}$

$\theta = 36.869...°$

Angle $= 37°$ (nearest degree)

(c) $v = (7i - 20j) + t(-5i + 12j)$

Compare with $v = u + at$:

$a = -5i + 12j$

(d) v parallel to $-5i + 8j$:

$\frac{7 - 5t}{12t - 20} = \frac{-5}{8}$

$8(7 - 5t) = -5(12t - 20)$

$56 - 40t = -60t + 100$

$20t = 44$

$t = 2.2$

(Check: $v = -4i + 6.4j = 0.8(-5i + 8j)$, same direction.)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 5 continued

Leave blank

Question 5 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 5 continued

(Total 13 marks)

Q5

Leave blank

6.

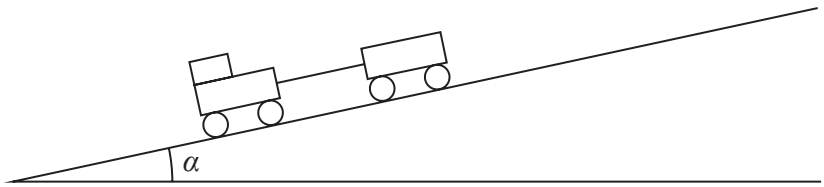


Figure 3

A railway engine of mass 1500 kg is attached to a railway truck of mass 500 kg by a straight rigid coupling. The engine pushes the truck up a straight track, which is inclined to the horizontal at an angle α, where $\sin\alpha = \frac{7}{25}$. The coupling is parallel to the track and parallel to the direction of motion, as shown in Figure 3.

The engine produces a constant driving force of magnitude D newtons. The engine and the truck experience constant resistances to motion, from non-gravitational forces, of magnitude 1200 N and 500 N respectively.

The thrust in the coupling is 2000 N.

The coupling is modelled as a light rod.

(a) Find the acceleration of the engine and the truck.

(4)

(b) Find the value of D.

(4)

(a) $\sin\alpha = \frac{7}{25}$. Acceleration up the track a m s^{-2}.

Truck, N2L up the slope (thrust 2000 N pushes it up):

$2000 - 500 - 500g\sin\alpha = 500a$

$2000 - 500 - 500 \times 9.8 \times \frac{7}{25} = 500a$

$2000 - 500 - 1372 = 500a$

$128 = 500a$

$a = 0.256 = 0.26$ m s^{-2} (2 s.f.)

(b) Engine, N2L up the slope (thrust 2000 N acts down on it):

$D - 1200 - 1500g\sin\alpha - 2000 = 1500a$

$D - 1200 - 1500 \times 9.8 \times \frac{7}{25} - 2000 = 1500 \times 0.256$

$D - 1200 - 4116 - 2000 = 384$

$D = 7700$

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 6 continued

Leave blank

Question 6 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 6 continued

Q6

(Total 8 marks)

Leave blank

7.

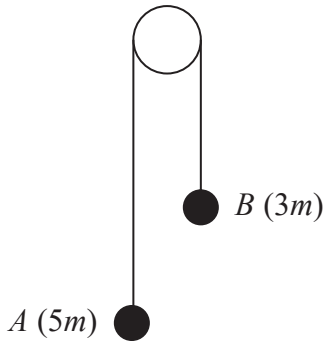


Figure 4

One end of a light inextensible string is attached to a particle A of mass $5m$. The other end of the string is attached to a particle B of mass $3m$. The string passes over a small, smooth, light fixed pulley. Particle A is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 4.

Particle A is released.

(a) Find, in terms of m and g, the magnitude of the force exerted on the pulley by the string while A is falling and before B hits the pulley.

(8)

(b) State how, in your solution to part (a), you have used the fact that the pulley is smooth.

(1)

(a) Let the acceleration be a and the tension T.

A (down): $5mg - T = 5ma$ ... (1)

B (up): $T - 3mg = 3ma$ ... (2)

(1) + (2): $2mg = 8ma \Rightarrow a = \frac{g}{4}$

$T = 3mg + 3m \times \frac{g}{4}$

$T = \frac{15mg}{4}$

Both parts of the string are vertical, so force on pulley = 2T

Force on pulley $= 2 \times \frac{15mg}{4} = \frac{15mg}{2}$

(b) The tension in the string is the same on both sides of the pulley.

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 7 continued

Leave blank

Question 7 continued

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 7 continued

Q7

(Total 9 marks)

Leave blank

8.

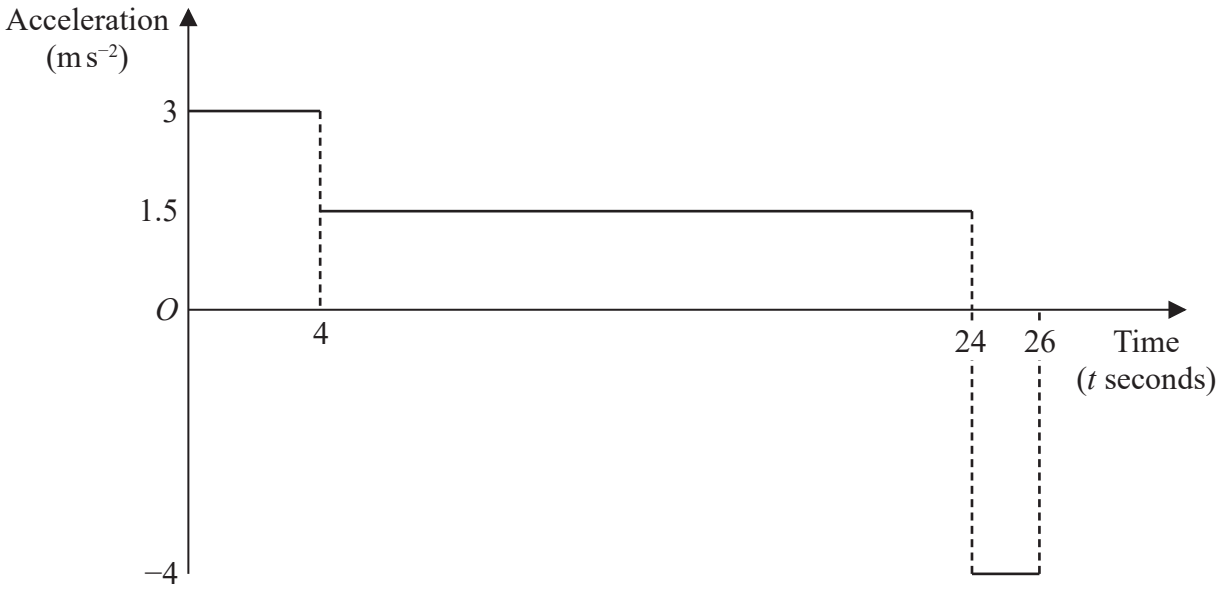


Figure 5

The acceleration-time graph shown in Figure 5 represents part of a journey made by a car along a straight horizontal road. The car accelerated from rest at time $t = 0$

(a) Find the distance travelled by the car during the first 4 s of its journey.

(2)

(b) Find the total distance travelled by the car during the first 26 s of its journey.

(6)

(a) From rest with $a = 3$ for 4 s:

$s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 3 \times 4^2$

Distance = 24 m

(b) At $t = 4$: $v = 0 + 3 \times 4 = 12$ m s^{-1}

At $t = 24$: $v = 12 + 1.5 \times 20 = 42$ m s^{-1}

At $t = 26$: $v = 42 - 4 \times 2 = 34$ m s^{-1}

4 to 24 s: $s = 12 \times 20 + \frac{1}{2} \times 1.5 \times 20^2 = 240 + 300 = 540$ m

24 to 26 s: $s = 42 \times 2 + \frac{1}{2} \times (-4) \times 2^2 = 84 - 8 = 76$ m

Total = 24 + 540 + 76

Total distance = 640 m

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 8 continued

Leave blank

Question 8 continued

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

Leave blank

Question 8 continued

Leave blank

Question 8 continued

Q8

(Total 8 marks)

TOTAL FOR PAPER = 75 MARKS

END

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA