AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname StemUp Model Solution

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Candidate signature _____

I declare this is my own work.

AS MATHEMATICS

Paper 1

Thursday 15 May 2025 Afternoon Time allowed: 1 hour 30 minutes

Materials
- You must have the AQA Formulae for A-level Mathematics booklet.
- You should have a graphical or scientific calculator that meets the requirements of the specification.

Instructions
- Use black ink or black ball-point pen. Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer each question in the space provided for that question.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do **not** write outside the box around each page or on blank pages.
- Show all necessary working; otherwise marks for method may be lost.
- Do all rough work in this book. Cross through any work that you do not want to be marked.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

Advice
- Unless stated otherwise, you may quote formulae, without proof, from the booklet.
- You do not necessarily need to use all the space provided.

For Examiner's Use	
Question	Mark
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TOTAL	

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Section A

Answer **all** questions in the spaces provided.

1 Identify the expression that is equivalent to $\tan x$

Circle your answer.

[1 mark]

$\sin^2 x + \cos^2 x$ $\quad$ $\sin^2 x - \cos^2 x$ $\quad$ $\dfrac{\cos x}{\sin x}$ $\quad$ $\dfrac{\sin x}{\cos x}$

2 Find the value of $\log_b \dfrac{1}{b^2}$

Circle your answer.

[1 mark]

-2 $\quad$ $-\dfrac{1}{2}$ $\quad$ $\dfrac{1}{2}$ $\quad$ 2

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3 The polynomial $p(x)$ is given by

$$p(x) = 2x^3 - ax^2 + 6x + 2a$$

It is given that $(x - 2)$ is a factor of $p(x)$

Find the value of a by using the factor theorem.

[3 marks]

$(x - 2)$ is a factor $\Rightarrow p(2) = 0$

$2(2)^3 - a(2)^2 + 6(2) + 2a = 0$

$16 - 4a + 12 + 2a = 0$

$28 - 2a = 0$

$a = 14$

Turn over for the next question

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4 Solve the equation

$$2\tan 3\theta - 3 = 0$$

for $0° \leq \theta \leq 180°$

Give your answers to the nearest degree.

[3 marks]

$2\tan 3\theta = 3 \Rightarrow \tan 3\theta = \frac{3}{2}$

$0° \leq \theta \leq 180° \Rightarrow 0° \leq 3\theta \leq 540°$

$3\theta = \tan^{-1}(1.5) = 56.309...°$

$3\theta = 56.31°,\ 56.31° + 180° = 236.31°,\ 56.31° + 360° = 416.31°$

$\theta = 18.77°,\ 78.77°,\ 138.77°$

$\theta = 19°,\ 79°,\ 139°$

5 Jayven claims that for two real numbers a and b

$$\text{if } a > b, \text{ then it must be true that } \frac{a}{b} > 1$$

By using a counter example, show that Jayven is **not** correct.

[2 marks]

Let $a = 1$ and $b = -1$, so $a > b$

$\frac{a}{b} = \frac{1}{-1} = -1$

$-1 < 1$, so $\frac{a}{b}$ is not greater than 1

$\therefore$ Jayven is not correct.

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6 It is given that $p = \log_2 x$ and $q = \log_2 y$

6 (a) Express

$$\log_2\left(\frac{x^2}{y}\right)$$

in terms of p and q

[2 marks]

$\log_2\left(\frac{x^2}{y}\right) = \log_2 x^2 - \log_2 y$

$= 2\log_2 x - \log_2 y$

$= 2p - q$

6 (b) Express

$$\log_2\left(16x^3\sqrt{y}\right)$$

in terms of p and q

Give your answer in a form not involving logarithms.

[3 marks]

$\log_2(16x^3\sqrt{y}) = \log_2(16x^3y^{1/2})$

$= \log_2 16 + \log_2 x^3 + \log_2 y^{1/2}$

$= 4 + 3\log_2 x + \frac{1}{2}\log_2 y$

$= 4 + 3p + \frac{1}{2}q$

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7 A circle has equation

$$(x-a)^2+(y-b)^2=49$$

7 (a) State the radius of the circle.

[1 mark]

$r^2 = 49 \Rightarrow r = \sqrt{49} = 7$

7 (b) The circle crosses the x-axis at two distinct points.

Find the range of possible values for b

[2 marks]

Centre (a, b), radius 7

Crosses x-axis twice when distance of centre from x-axis < radius

$|b| < 7$

$-7 < b < 7$

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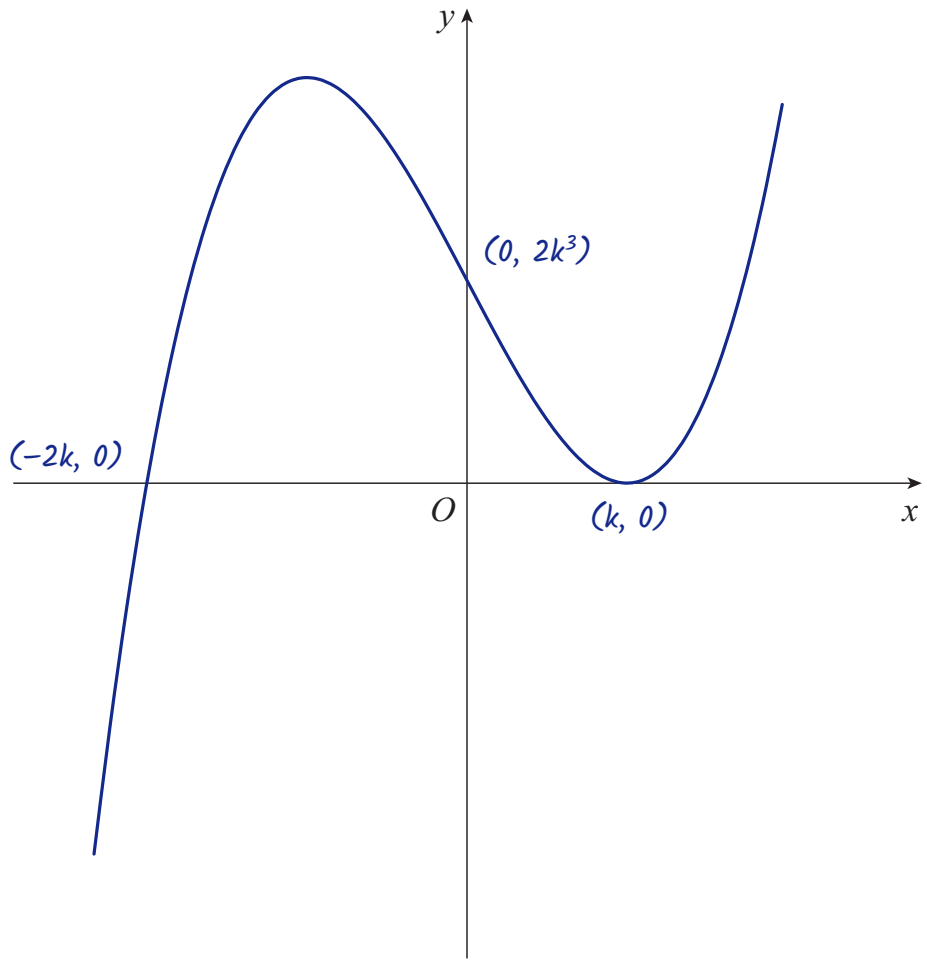
8 Sketch the graph of

$$y = (x - k)^2(x + 2k)$$

where k is a positive constant.

Label the coordinates of the points where the graph meets the axes.

[4 marks]



Turn over for the next question

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9 (a) Find, in ascending powers of x, the first three terms in the expansion of

$$(1 - 5x)^7$$

[3 marks]

$(1 - 5x)^7 = 1 + {}^7C_1(-5x) + {}^7C_2(-5x)^2 + \ldots$

$= 1 + 7(-5x) + 21(25x^2) + \ldots$

$= 1 - 35x + 525x^2 + \ldots$

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9 (b) The coefficient of x^2 in the expansion of

$$(3 + kx)(1 - 5x)^7$$

is 1477

Find the value of k

[3 marks]

$(3 + kx)(1 - 35x + 525x^2 + \ldots)$

x^2 terms: $3 \times 525x^2 + kx \times (-35x)$

Coefficient of x^2: $1575 - 35k = 1477$

$-35k = -98$

$k = \frac{98}{35} = \frac{14}{5}$

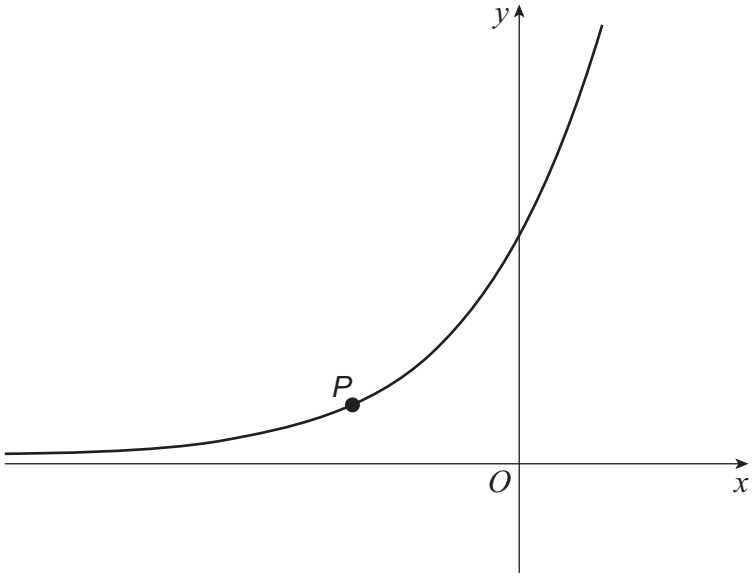
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10 A curve has the equation

$$y = e^{3x}$$

and the point P lies on the curve, as shown in the diagram.



The tangent to the curve at P is parallel to the line with equation $x - 9y = 23$

Find the x-coordinate of P

[5 marks]

$x - 9y = 23 \Rightarrow y = \frac{1}{9}x - \frac{23}{9}$

Gradient of tangent = gradient of line = $\frac{1}{9}$

$y = e^{3x} \Rightarrow \frac{dy}{dx} = 3e^{3x}$

$3e^{3x} = \frac{1}{9}$

$e^{3x} = \frac{1}{27}$

$3x = \ln \frac{1}{27}$

$x = \frac{1}{3} \ln \frac{1}{27} = \ln \frac{1}{3}$

$x = \ln \frac{1}{3} \quad (= -\ln 3 \approx -1.10)$

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11 (a) Expand $x(x-2)(x+4)$

[1 mark]

$x(x-2)(x+4) = x(x^2+2x-8)$

$= x^3+2x^2-8x$

11 (b) Show that

$$\int_{-4}^{2} x(x-2)(x+4)\,dx = 36$$

Fully justify your answer.

[4 marks]

$\int_{-4}^{2} x(x-2)(x+4)\,dx = \int_{-4}^{2} (x^3+2x^2-8x)\,dx$

$= \left[\frac{x^4}{4} + \frac{2x^3}{3} - 4x^2\right]_{-4}^{2}$

$= \left(\frac{(2)^4}{4} + \frac{2(2)^3}{3} - 4(2)^2\right) - \left(\frac{(-4)^4}{4} + \frac{2(-4)^3}{3} - 4(-4)^2\right)$

$= \left(4 + \frac{16}{3} - 16\right) - \left(64 - \frac{128}{3} - 64\right)$

$= \left(-\frac{20}{3}\right) - \left(-\frac{128}{3}\right)$

$= \frac{108}{3} = 36$ as required

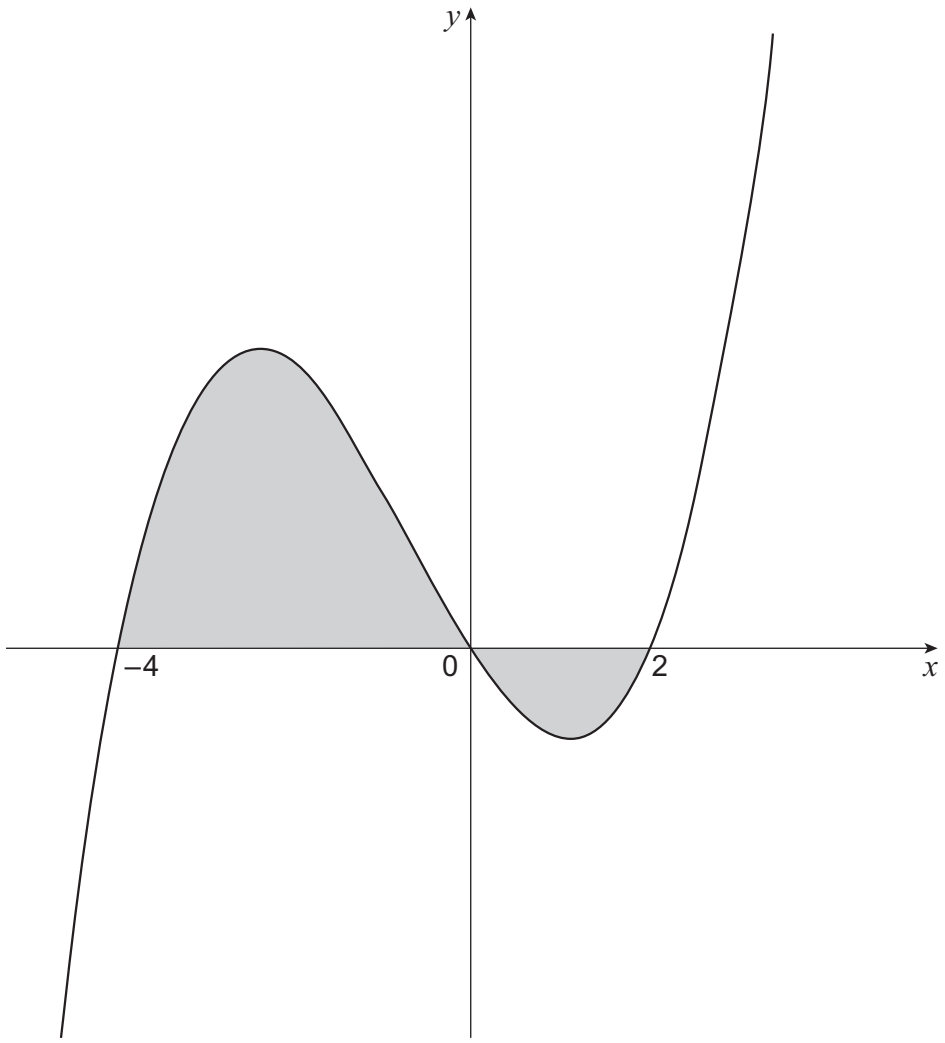
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11 (c) The curve C has equation

$$y = x(x - 2)(x + 4)$$

A sketch of C is shown in the diagram.



11 (c) (i) Explain why your answer to part **(b)** will not give the total area of the shaded region bounded by C and the x-axis.

[1 mark]

The region is partly above and partly below the x-axis. The integral of the part below the axis gives a negative value, so it is subtracted, and a single integral from −4 to 2 does not give the total area.

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11 (c) (ii) Find the total area of the shaded region bounded by C and the x-axis.

[2 marks]

$\int_0^2 (x^3 + 2x^2 - 8x)\,dx = \left[\frac{x^4}{4} + \frac{2x^3}{3} - 4x^2\right]_0^2$

$= 4 + \frac{16}{3} - 16 = -\frac{20}{3}$

$\int_{-4}^0 (x^3 + 2x^2 - 8x)\,dx = 0 - \left(64 - \frac{128}{3} - 64\right) = \frac{128}{3}$

Total area $= \frac{128}{3} + \frac{20}{3}$

$= \frac{148}{3} \quad (\approx 49.3)$

Turn over for the next question

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12 (a) It is given that

$$^{40}C_{18} = \frac{40!}{18!\,p!}$$

Write down the value of p

[1 mark]

$^{40}C_{18} = \frac{40!}{18!(40-18)!} \Rightarrow p = 22$

12 (b) Use the result from part **(a)** to show that

$$\frac{^{40}C_{18}}{^{40}C_{17}} = \frac{23}{q}$$

where q is an integer to be found.

[2 marks]

$^{40}C_{17} = \frac{40!}{17!\,23!}$

$\frac{^{40}C_{18}}{^{40}C_{17}} = \frac{40!}{18!\,22!} \times \frac{17!\,23!}{40!}$

$= \frac{17!\,23!}{18!\,22!} = \frac{17! \times 23 \times 22!}{18 \times 17! \times 22!}$

$= \frac{23}{18}$

$\therefore q = 18$

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13 A computer game awards points to a player based on the time taken to complete a level.

The points awarded decrease as the time taken to complete a level increases.

Rebekah believes that the points awarded, P, can be modelled by the equation

$$P = Ae^{kt}$$

where t is the time, in seconds, taken to complete the level and A and k are constants.

13 (a) Explain, in context, the meaning of the value of A

[1 mark]

A is the number of points awarded when t = 0, i.e. the points available at the start of the level (the maximum points).

13 (b) Show that

$$\ln P = \ln A + kt$$

[2 marks]

$P = Ae^{kt}$

$\ln P = \ln(Ae^{kt})$

$\ln P = \ln A + \ln e^{kt}$

$\ln P = \ln A + kt$

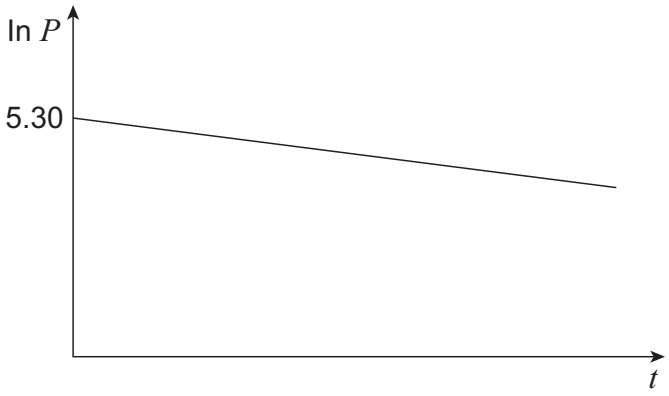
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13 (c) Rebekah records the points and the time taken for her to complete each level.

She plots the values of ln P against t

Rebekah obtains a straight-line graph with a gradient of -0.08 and a vertical intercept of 5.30, as shown in the diagram.



Find the value of A and the value of k

[3 marks]

ln P = kt + ln A is a straight line, gradient k, intercept ln A

Gradient: k = −0.08

Intercept: ln A = 5.30

$A = e^{5.30} = 200.33...$

A = 200, k = −0.08

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13 (d) Rebekah scores 20 points for completing a particular level.

Find, to the nearest second, the time taken to complete this level.

[3 marks]

$200e^{-0.08t} = 20$

$e^{-0.08t} = \frac{1}{10}$

$-0.08t = \ln \frac{1}{10}$

$t = \frac{\ln 0.1}{-0.08} = 28.78...$

Time taken = 29 seconds (to the nearest second)

END OF SECTION A

Turn over for Section B

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Section B

Answer **all** questions in the spaces provided.

14 A particle of mass 2 kg is moving on a smooth horizontal surface under the action of a single horizontal force of 5 N

Find the acceleration of the particle.

Circle your answer.

[1 mark]

0.4 m s^{-2} | 2.5 m s^{-2} | 10 m s^{-2} | 24.5 m s^{-2}

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15 Three forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ are given by:

$$\mathbf{F}_1 = (-2\mathbf{i} + 4\mathbf{j})\ \text{N}$$

$$\mathbf{F}_2 = (-3\mathbf{i} + 6\mathbf{j})\ \text{N}$$

$$\mathbf{F}_3 = (-6\mathbf{i} + 9\mathbf{j})\ \text{N}$$

One of the following statements is true.

Identify the correct statement.

Tick (✓) **one** box.

[1 mark]

$\mathbf{F}_1$ and $\mathbf{F}_2$ are parallel forces. ☑

$\mathbf{F}_1$ and $\mathbf{F}_3$ are parallel forces. ☐

$\mathbf{F}_2$ and $\mathbf{F}_3$ are parallel forces. ☐

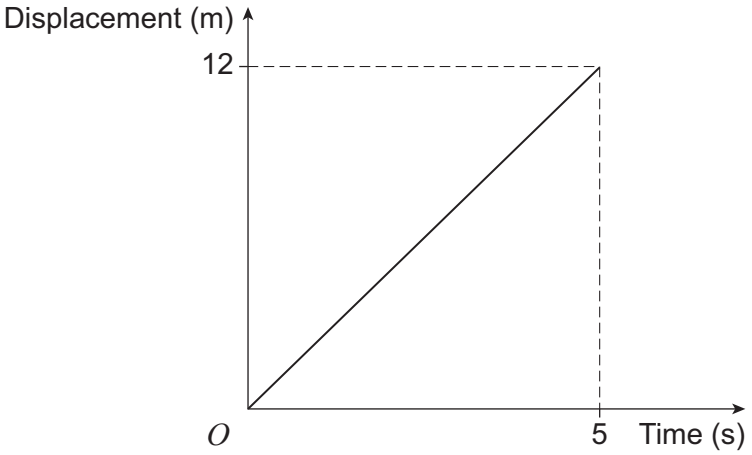
None of the forces $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ are parallel. ☐

Turn over for the next question

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16 The displacement–time graph, **Figure 1**, shows the first 5 seconds of the motion of a car which starts from rest and travels 12 metres.

Figure 1



16 (a) Find the speed of the car.

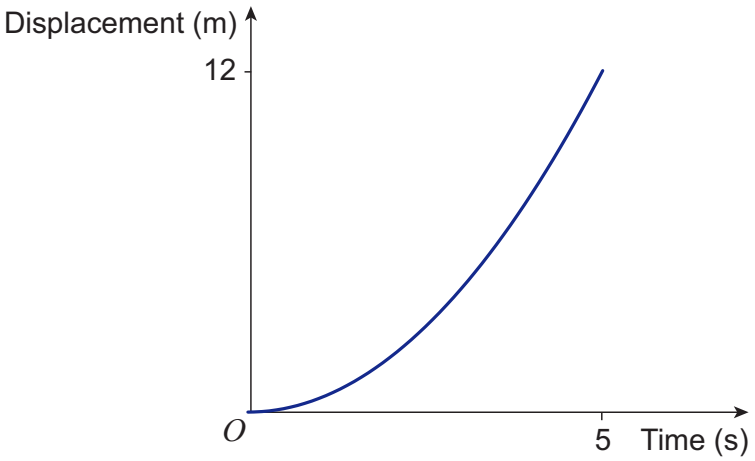
[1 mark]

Speed = $\frac{12}{5}$ = 2.4 m s^{-1}

16 (b) On **Figure 2**, draw a more realistic displacement–time graph to show the first 5 seconds of motion of the car.

[1 mark]

Figure 2



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17 **In this question use $g = 9.8$ m s^{-2}**

Lamic has mass 60 kg.

He is standing on the floor of a lift.

The lift is accelerating upwards at 1.2 m s^{-2}

The reaction of the floor on Lamic is R newtons.

Find the value of R

[2 marks]

Resolving vertically (upwards positive), $F = ma$:

$R - 60g = 60 \times 1.2$

$R - 60(9.8) = 72$

$R = 588 + 72 = 660$

Turn over for the next question

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18 **In this question use $g = 10$ m s^{-2}**

A ball is thrown vertically upwards from a height of 1.8 metres above the ground.

The initial velocity of the ball is 12 m s^{-1}

The greatest height reached by the ball above the ground is h metres.

Find the value of h

[3 marks]

Upwards positive: $u = 12$, $v = 0$, $a = -10$, $s = ?$

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

$0^2 = 12^2 + 2(-10)s$

$20s = 144 \Rightarrow s = 7.2$ m

$h = 7.2 + 1.8 = 9$

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19 A force **F** is $\begin{bmatrix} p \\ -0.5 \end{bmatrix}$ newtons, where p is a constant.

Given that the magnitude of **F** is 1.3 newtons, find the possible values of p

[3 marks]

$|F| = \sqrt{(p^2 + (-0.5)^2)} = 1.3$

$p^2 + 0.25 = 1.69$

$p^2 = 1.44$

$p = 1.2$ or $p = -1.2$

Turn over for the next question

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20 A sports scientist is modelling the speed of an athlete who ran a 100-metre race.

The speed, v m s^{-1}, of the athlete at time t seconds after the start of the 100-metre race is given by

$$v = 1.8 + 3.8t - 0.25t^2$$

20 (a) State the initial speed of the athlete according to the model.

[1 mark]

$t = 0$: $v = 1.8 + 3.8(0) - 0.25(0)^2 = 1.8$ m s^{-1}

20 (b) (i) Find an expression, in terms of t, for the acceleration of the athlete.

[2 marks]

$v = 1.8 + 3.8t - 0.25t^2$

$a = \frac{dv}{dt} = 3.8 - 0.5t$

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20 (b) (ii) Hence find the maximum speed of the athlete.

Fully justify your answer.

[4 marks]

Maximum speed when $a = \frac{dv}{dt} = 0$

$3.8 - 0.5t = 0 \Rightarrow t = 7.6$

$\frac{d^2v}{dt^2} = -0.5 < 0$, so this is a maximum

$v = 1.8 + 3.8(7.6) - 0.25(7.6)^2$

$= 1.8 + 28.88 - 14.44$

$= 16.24$

Maximum speed = 16.2 m s^{-1}

20 (c) The official maximum speed recorded, by the scientist, for the athlete was 12.4 m s^{-1}

Evaluate the accuracy of the model used by the scientist.

[1 mark]

16.2 m s^{-1} is much greater than 12.4 m s^{-1}, so the model overestimates the maximum speed significantly; it is not accurate.

Turn over for the next question

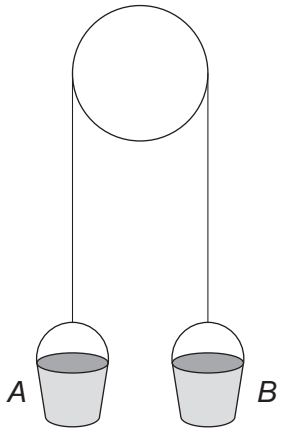
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21 Two buckets, *A* and *B*, each have mass 0.5 kg

Each bucket is attached to one end of a light inextensible rope.

The rope is hung over a smooth fixed pulley.

The system is in equilibrium with both buckets hanging freely at rest, as shown in the diagram.



A builder then places a brick of mass 3 kg inside bucket *A*

Bucket *A*, with the brick inside, then moves vertically downwards.

During the subsequent motion, the magnitude of the acceleration of each bucket is a m s^{-2} and the magnitude of the tension in the rope is T N

Assume the buckets and brick can be modelled as particles.

21 (a) Find a and T, leaving your answers in terms of g

Fully justify your answer.

[6 marks]

Rope light, pulley smooth ⇒ tension T is the same on both sides;

rope inextensible ⇒ both buckets have the same acceleration a.

A (mass 0.5 + 3 = 3.5 kg), downwards: $3.5g - T = 3.5a$ (1)

B (mass 0.5 kg), upwards: $T - 0.5g = 0.5a$ (2)

(1) + (2): $3g = 4a$

$a = \frac{3g}{4}$

Sub into (2): $T = 0.5g + 0.5 \times \frac{3g}{4}$

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$T = 0.5g + \frac{3g}{8}$

$T = \frac{7g}{8}$

$a = \frac{3g}{4}\ m\ s^{-2}, \quad T = \frac{7g}{8}\ N$

21 (b) Explain a limitation of modelling the buckets as particles.

[1 mark]

The buckets are not points: they have size, so modelling them as particles ignores their dimensions (e.g. they could swing or rotate, and air resistance on them is ignored).

END OF QUESTIONS

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