Mechanics Year 1 exam questions (AS maths) - AQA

NOTE:
Please be aware that in the Year 12 collections, you will find questions from the Year 13 papers. However, these questions are intentionally included because they align with Year 12 content and topics.
Happy studying!

Arancha Ruiz

Ch 20 Forces and Newton's laws of motion

June 2023 Question 16 Paper 2 (a-level)

16 A particle moves under the action of two forces, $\mathbf{F}_1$ and $\mathbf{F}_2$

It is given that

$$\mathbf{F}_1 = (1.6\mathbf{i} - 5\mathbf{j})\,\mathrm{N}$$
$$\mathbf{F}_2 = (k\mathbf{i} + 5k\mathbf{j})\,\mathrm{N}$$

where k is a constant.

The acceleration of the particle is $(3.2\mathbf{i} + 12\mathbf{j})\,\mathrm{m\,s^{-2}}$

Find k

[4 marks]

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
16	Adds the two forces together. ACF	1.1b	B1	$\mathbf{F}_1 + \mathbf{F}_2 = \begin{bmatrix} 1.6+k \\ 5k-5 \end{bmatrix}$
	Uses $\mathbf{F} = m\boldsymbol{a}$ and substitutes their $\mathbf{F}_1 \pm \mathbf{F}_2$ and $\boldsymbol{a} = \begin{bmatrix} 3.2 \\ 12 \end{bmatrix}$ PI by use of ratios For example: $\frac{5k-5}{12} = \frac{1.6+k}{3.2}$ OE	3.1a	M1	$\begin{bmatrix} 1.6+k \\ 5k-5 \end{bmatrix} = m \begin{bmatrix} 3.2 \\ 12 \end{bmatrix}$ $1.6+k = 3.2m$ $5k-5 = 12m$ $k = 8.8$
	Obtains two correct equations For example: $1.6+k = 3.2m$ **and** $5k-5 = 12m$ Only award if vectors are removed or Obtains a correct linear equation in k For example: $\frac{5k-5}{12} = \frac{1.6+k}{3.2}$ OE PI by $k = 8.8$ or $m = 3.25$	1.1b	A1	
	Obtains $k = 8.8$ ACF	1.1b	A1	
	Question 16 Total		**4**	

June 2023 Question 11 Paper 2 (a-level)

11 A decoration is hanging freely from a fixed point on a ceiling.

The decoration has a mass of 0.2 kilograms.

The decoration is hanging by a light, inextensible wire.

The wire is 0.1 metres long.

Find the tension in the wire.

Circle your answer.

[1 mark]

$0.02\,\text{N}$ $\quad$ $0.02g\,\text{N}$ $\quad$ $0.2\,\text{N}$ $\quad$ $0.2g\,\text{N}$

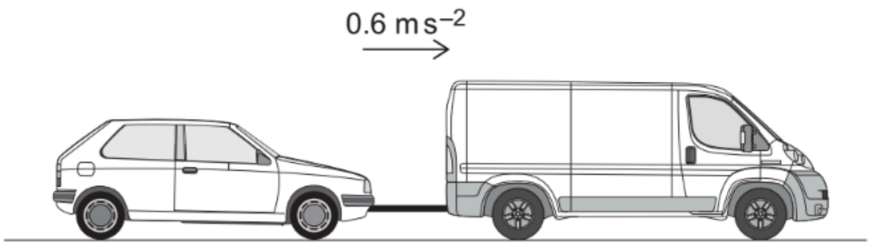
ANSWER

Q	Marking instructions	AO	Marks	Typical solution
11	Circles correct answer	1.2	B1	$0.2g$ N
	Question 11 Total		**1**	

June 2023 Question 18 Paper 1

18 A rescue van is towing a broken-down car by using a tow bar.

The van and the car are moving with a constant acceleration of $0.6\,\text{m s}^{-2}$ along a straight horizontal road as shown in the diagram below.



The van has a total mass of 2780 kg

The car has a total mass of 1620 kg

The van experiences a driving force of D newtons.

The van experiences a total resistance force of R newtons.

The car experiences a total resistance force of $0.6R$ newtons.

18 (a) The tension in the tow bar, T newtons, may be modelled by

$$T = kD - 18$$

where k is a constant.

Find k

[5 marks]

18 (b) State one assumption that must be made in answering part **(a)**.

[1 mark]

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
18(a)	Uses $F = ma$ to form at least one equation modelling the van, car or both combined with at least three terms.	3.3	M1	$D - R - T = 2780 \times 0.6$
	Obtains a fully correct equation. Other examples: $D - R - T = 1668$ $T - 0.6R = 972$ $D - 1.6R = 2640$ NB T may have been replaced by $kD - 18$ at any point.	1.1b	A1	$T - 0.6R = 1620 \times 0.6$ Eliminating R $0.6D - 1.6T = 28.8$
	Forms a second fully correct equation.	3.3	B1	$T = \frac{0.6}{1.6}(D - 48)$
	Eliminates R to form an equation with D and T	3.4	M1	$k = \frac{3}{8}$
	Obtains $k = \frac{3}{8}$ OE	1.1b	A1	
	Subtotal		**5**	

Q	Marking instructions	AO	Marks	Typical solution
18(b)	Describes any valid assumption. For example: • Tow bar has negligible mass. • The car is directly behind the van. • The masses include drivers. • Tow bar is rigid. • Tow bar is inextensible. • Do not accept any reference to resistances, tension being constant, tow bar breaks.	3.5b	B1	Tow bar is horizontal
	Subtotal		**1**	

June 2023 Question 17 Paper 1

17 A particle, P, is initially at rest on a smooth horizontal surface.

A resultant force of $\begin{bmatrix} 12 \\ 9 \end{bmatrix}$ N is then applied to P, so that it moves in a straight line.

17 (a) Find the magnitude of the resultant force.

[1 mark]

17 (b) Two fixed points A and B have position vectors

$$\overrightarrow{OA} = \begin{bmatrix} 3 \\ 7 \end{bmatrix} \text{ metres} \qquad \text{and} \qquad \overrightarrow{OB} = \begin{bmatrix} k \\ k-1 \end{bmatrix} \text{ metres}$$

with respect to a fixed origin, O

P moves in a straight line parallel to $\overrightarrow{AB}$

17 (b) (i) Find $\overrightarrow{AB}$ in terms of k

[1 mark]

17 (b) (ii) Find the value of k

[2 marks]

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
17(a)	Finds correct magnitude of force. Condone omission of units	1.1b	B1	$\sqrt{12^2+9^2}=15$ N
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
17(b)(i)	Forms correct expression for $\overrightarrow{AB}$ Condone omission of units	1.1b	B1	$\overrightarrow{AB}=\begin{bmatrix}k-3\\k-8\end{bmatrix}$ metres
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
17(b)(ii)	Deduces $\overrightarrow{AB}$ is a scalar multiple of $\begin{bmatrix}12\\9\end{bmatrix}$	2.2a	M1	Since direction of movement is in direction of force then $\overrightarrow{AB}$ is a scalar multiple of $\begin{bmatrix}12\\9\end{bmatrix}$ $\begin{bmatrix}k-3\\k-8\end{bmatrix}=\begin{bmatrix}12\lambda\\9\lambda\end{bmatrix}$ $9(k-3)=12(k-8)$ $9k-27=12k-96$ $k=23$
	Deduces $k=23$ FT their answer to part (b)(i)	2.2a	A1F	
	Subtotal		**2**	

June 2023 Question 13 Paper 1

13 A resultant force of $\begin{bmatrix} -2 \\ 6 \end{bmatrix}$ N acts on a particle.

The acceleration of the particle is $\begin{bmatrix} -6 \\ y \end{bmatrix}$ m s^{-2}

Find the value of y

Circle your answer.

[1 mark]

2 3 10 18

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
13	Circles correct answer	1.1b	B1	18
	Question 13 Total		**1**	

June 2022 Question 13 Paper 1

13 Two points A and B lie in a horizontal plane and have coordinates $(-2, 7)$ and $(3, 19)$ respectively.

A particle moves in a straight line from A to B under the action of a constant resultant force of magnitude 6.5 N

Express the resultant force in vector form.

[3 marks]

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
13	Finds the vector $\overrightarrow{AB}$ with at least one component correct PI by the modulus calculation ACF	1.1a	M1	$\overrightarrow{AB} = 5\mathbf{i} + 12\mathbf{j}$
	Uses Pythagoras to determine their $\lvert\overrightarrow{AB}\rvert$ Condone notation errors for modulus.	1.1a	M1	$\lvert\overrightarrow{AB}\rvert = \sqrt{5^2 + 12^2} = 13$
	Finds the correct force vector. Condone missing units. ACF	1.1b	A1	So $\boldsymbol{F} = \frac{6.5}{13}(5\mathbf{i} + 12\mathbf{j})$ $2.5\mathbf{i} + 6\mathbf{j}$ N
	Question 13 Total		**3**	

June 2022 Question 12 Paper 1

12 A horizontal force of 30 N causes a crate to travel with an acceleration of $2\,\mathrm{m\,s^{-2}}$, in a straight line, on a smooth horizontal surface.

Find the **weight** of the crate.

Circle your answer.

[1 mark]

15 kg 15g N 15 N 15g kg

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
12	Circles correct answer.	1.1b	B1	15g N
	Question 12 Total		**1**	

June 2022 Question 15 Paper 1

15 Two particles, P and Q, are initially at rest at the same point on a horizontal plane.

A force of $\begin{bmatrix} 4 \\ 0 \end{bmatrix}$ N is applied to P.

A force of $\begin{bmatrix} 8 \\ 15 \end{bmatrix}$ N is applied to Q.

15 (a) Calculate, to the nearest degree, the acute angle between the two forces.

[2 marks]

15 (b) The particles begin to move under the action of the respective forces.

P and Q have the same mass.

P has an acceleration of magnitude $5\,\text{m s}^{-2}$

Find the magnitude of the acceleration of Q.

[3 marks]

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
15(a)	Uses trigonometry to find angle above **i** for path of Q PI by 51° (AWRT) or 75° (AWRT)	1.1a	M1	Q angle = $\tan^{-1}\left(\frac{15}{8}\right)$
	Obtains correct angle AWRT 62°	1.1b	A1	Angle between paths = 62°
	Subtotal		**2**	

Q	Marking instructions	AO	Marks	Typical solution
15(b)	Obtains m = 0.8	3.1b	B1	$4 = 5m \implies m = 0.8$ kg $\sqrt{8^2 + 15^2} = 17$ $17 = 0.8a \implies a = 21.25$ m s^{-2}
	Uses $F = ma$ for Q for their m ACF	1.1a	M1	
	Obtains a = 21.25 Condone missing units CAO	1.1b	A1	
	Subtotal		**3**	

June 2022 Question 17 Paper 1

In the next chapter, as it has variable acceleration. Click here.

November 2021 Question 15 Paper 1

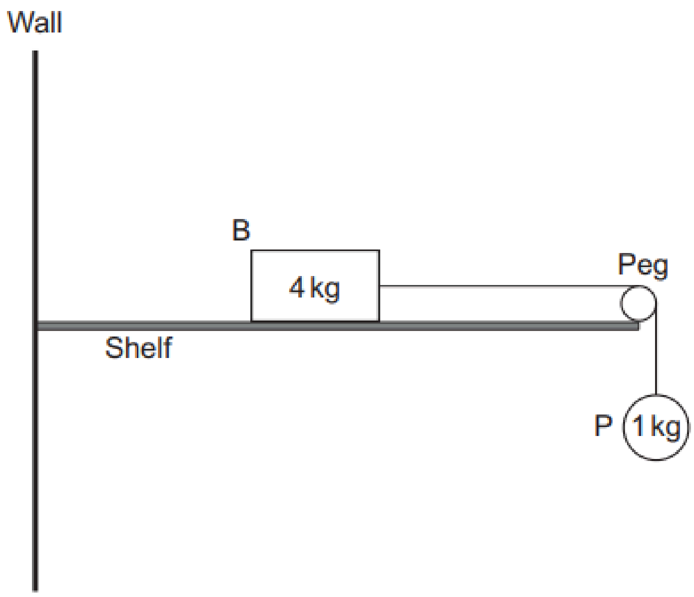
15 **In this question, use $g = 10\,\text{m}\,\text{s}^{-2}$**

A box, B, of mass 4 kg lies at rest on a fixed rough horizontal shelf.

One end of a light string is connected to B.

The string passes over a smooth peg, attached to the end of the shelf.

The other end of the string is connected to particle, P, of mass 1 kg, which hangs freely below the shelf as shown in the diagram below.



B is initially held at rest with the string taut.

B is then released.

B and P both move with constant acceleration $a\,\text{m}\,\text{s}^{-2}$

As B moves across the shelf it experiences a **total** resistance force of 5 N

15 (a) State one type of force that would be included in the total resistance force.

[1 mark]

15 (b) Show that $a = 1$

[4 marks]

15 (c) When B has moved forward exactly 20 cm the string breaks.

Find how much further B travels before coming to rest.

[4 marks]

15 (d) State one assumption **you** have made when finding your solutions in parts **(b)** or **(c)**.

[1 mark]

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
15(a)	States either friction or air resistance or both but no incorrect forces.	3.3	B1	Friction
	Subtotal		**1**	

Q	Marking instructions	AO	Marks	Typical solution
15(b)	Uses $F = ma$ to form a three term equation modelling the motion of P	3.3	M1	$10 - T = 1 \times a$ $T - 5 = 4 \times a$ $5 = 5a$ $a = 1$
	Uses $F = ma$ to form a three term equation modelling the motion of B	3.3	M1	
	Obtains two correct equations	1.1b	A1	
	Completes a rigorous argument to show that $a = 1$	2.1	R1	
	Subtotal		**4**	

15(c)	Uses appropriate suvat equation with given values to find v or v^2	3.3	M1	$v^2 = 0 + 2 \times 1 \times 0.2 = 0.4$
	Uses $F = ma$ to find acceleration of B after string breaks	3.4	M1	$-5 = 4a$ $a = -1.25$
	Obtains $a = -1.25$	1.1b	A1	$0^2 = 0.4 + (2)(-1.25)s$
	Uses appropriate suvat equation to obtain 0.16m. Must include units.	1.1b	A1	$s = 0.16$ m $s = 0.2$ m, to 1 sf
	Subtotal		**4**	

Q	Marking instructions	AO	Marks	Typical solution
15(d)	States a valid assumption Accept: • No air resistance to motion of P • string remains parallel to table • B does not reach end of table before it stops • P does not hit floor before string breaks	3.5b	E1	String is inextensible
	Subtotal		**1**	

Video solution:

https://youtu.be/vk-nKdD3Xlw

November 2021 Question 13 Paper 2 (a-level)

13 A vehicle, of total mass 1200 kg, is travelling along a straight, horizontal road at a constant speed of 13 m s^{-1}

This vehicle begins to accelerate at a constant rate.

After 40 metres it reaches a speed of 17 m s^{-1}

Find the resultant force acting on the vehicle during the period of acceleration.

[3 marks]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
13	Selects and uses an appropriate constant acceleration equation to find the acceleration. Must have substituted at least two values correctly	3.1b	M1	$v^2 = u^2 + 2as$ $289 = 169 + 80a$ $\Rightarrow a = 1.5$ $\mathrm{F} = 1200 \times 1.5 = 1800\ \mathrm{N}$
	Obtains $a = 1.5$ PI by correct F	1.1b	A1	
	Substitutes their value of a into $\mathrm{F} = ma$ to obtain their F Condone missing or incorrect units	1.1b	B1F	
	Total		**3**	

November 2020 Question 14 Paper 1

14 A particle of mass 0.1 kg is initially stationary.

A single force **F** acts on this particle in a direction parallel to the vector $7\mathbf{i} + 24\mathbf{j}$

As a result, the particle accelerates in a straight line, reaching a speed of $4\,\text{m s}^{-1}$ after travelling a distance of 3.2 m

Find **F**.

[5 marks]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
14	Uses appropriate constant acceleration equation to find the acceleration	3.4	M1	$v^2 = u^2 + 2as$ Using $s = 3.2, u = 0$ and $v = 4$
	Obtains correct value for a	1.1b	A1	$a = 2.5$
	Uses their a value with Newton's second Law to determine magnitude of force	3.4	M1	$F = ma \Rightarrow F = 0.25$
	Calculates the magnitude of the given vector	1.1b	B1	$\sqrt{7^2 + 24^2} = 25$
	Deduces, using given information, correct vector form of the force	2.2a	A1	$\mathbf{F} = \frac{1}{100}(7\mathbf{i} + 24\mathbf{j})$
	Total		**5**	

November 2020 Question 16 Paper 1

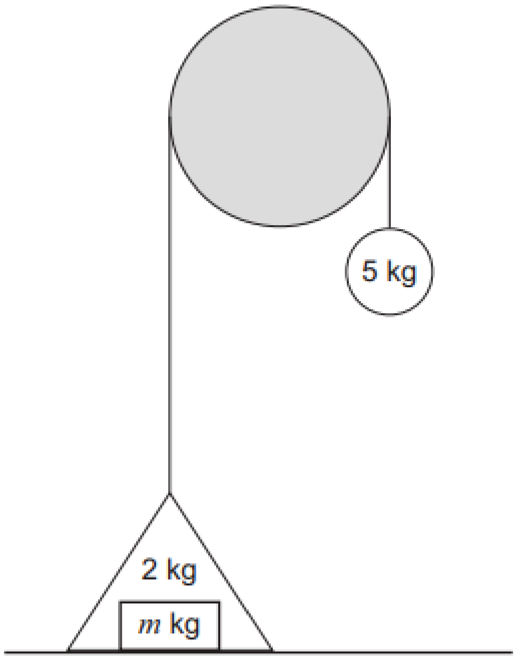
16 A simple lifting mechanism comprises a light inextensible wire which is passed over a smooth fixed pulley.

One end of the wire is attached to a rigid triangular container of mass 2 kg, which rests on horizontal ground.

A load of m kg is placed in the container.

The other end of the wire is attached to a particle of mass 5 kg, which hangs vertically downwards.

The mechanism is initially held at rest as shown in the diagram below.



The mechanism is released from rest, and the container begins to move upwards with acceleration a m s^{-2}

The wire remains taut throughout the motion.

16 (a) Show that

$$a = \left(\frac{3 - m}{m + 7}\right) g$$

[4 marks]

16 (b) State the range of possible values of m.

[1 mark]

16 (c) **In this question use $g = 9.8 \text{ m s}^{-2}$**

The load reaches a height of 2 metres above the ground 1 second after it is released.

Find the mass of the load.

[4 marks]

16 (d) Ignoring air resistance, describe **one** assumption you have made in your model.

[1 mark]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
16(a)	Models the motion of the container and load with at least one side of the equation correct.	3.3	M1	$T-(m+2)g=(m+2)a$
	Forms fully correct equation	1.1b	A1	
	Forms fully correct equation for particle	3.3	B1	$5g-T=5a$
	Completes a rigorous argument by eliminating T and rearranging to express a in terms of m. AG	2.1	R1	$5g-(m+2)g=(5+2+m)a$ $(3-m)g=(7+m)a$ $\therefore a=\left(\frac{3-m}{m+7}\right)g$
	Subtotal		**4**	
16(b)	Deduces correct limits Condone $0 \le m < 3$	2.2a	B1	$0<m<3$
	Subtotal		**1**	
16(c)	Uses appropriate constant acceleration equation to find the acceleration	3.4	M1	$s=ut+\frac{1}{2}at^2$
	Calculates correct value for a	1.1b	A1	Using $s=2, u=0$ and $t=1$ $a=4$
	Forms equation for a in terms of m using their a value	3.4	M1	$4=\left(\frac{3-m}{m+7}\right)g$
	Solves to find m. AWRT 0.10 Condone 0.1	3.2a	A1	$m=\frac{3g-28}{4+g}=0.10$ kg
16(d)	Describes any valid assumption not related to those assumptions already stated in the question. Eg The particle is at least 2m above the ground Eg The particle does not collide with the load	3.5b	E1	I assumed that the top of the container does not reach the pulley
	Subtotal		**1**	
	Question Total		**10**	

Video solution:
https://youtu.be/Hra4-ig_D4I

November 2021 Question 10 Paper 1

10 Two forces $\begin{bmatrix} 3 \\ -2 \end{bmatrix}$ N and $\begin{bmatrix} -7 \\ -5 \end{bmatrix}$ N act on a particle.

Find the resultant force.

Circle your answer.

[1 mark]

$\begin{bmatrix} -21 \\ 10 \end{bmatrix}$ N $\quad$ $\begin{bmatrix} -4 \\ -7 \end{bmatrix}$ N $\quad$ $\begin{bmatrix} 4 \\ 3 \end{bmatrix}$ N $\quad$ $\begin{bmatrix} 10 \\ 7 \end{bmatrix}$ N

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
10	Circles correct answer	1.1b	B1	$\begin{bmatrix} -4 \\ -7 \end{bmatrix}$ N
	Total		**1**	

November 2021 Question 11 Paper 1

11 Jackie says:

"A person's weight on Earth is directly proportional to their mass."

Tom says:

"A person's weight on Earth is different to their weight on the moon."

Only one of the statements below is correct.

Identify the correct statement.

Tick (✓) **one** box.

[1 mark]

Jackie and Tom are both wrong. ☐

Jackie is right but Tom is wrong. ☐

Jackie is wrong but Tom is right. ☐

Jackie and Tom are both right. ☐

ANSWER

Q	Marking instructions	AO	Marks	Typical solution
11	Ticks correct box	2.2a	B1	Jackie and Tom are both right
	Total		**1**	

November 2021 Question 10 Paper 2 (a-level)

10 A vehicle is driven at a constant speed of $12\,\mathrm{m\,s^{-1}}$ along a straight horizontal road.

Only one of the statements below is correct.

Identify the correct statement.

Tick (✓) **one** box.

[1 mark]

The vehicle is accelerating ☐

The vehicle's driving force exceeds the total force resisting its motion ☐

The resultant force acting on the vehicle is zero ☐

The resultant force acting on the vehicle is dependent on its mass ☐

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
10	Ticks correct box	1.2	B1	The resultant force acting on the vehicle is zero
	Total		**1**	

November 2020 Question 11 Paper 1

11 A go-kart and driver, of combined mass 55 kg, move forward in a straight line with a constant acceleration of $0.2\,\mathrm{m\,s^{-2}}$

The total driving force is 14 N

Find the total resistance force acting on the go-kart and driver.

Circle your answer.

[1 mark]

0 N   3 N   11 N   14 N

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
11	Circles correct answer	AO1.1b	B1	a = 28
	Total		**1**	

June 2019 Question 12 Paper 1

12 A particle P, of mass m kilograms, is attached to one end of a light inextensible string.

The other end of this string is held at a fixed position, O.

P hangs freely, in equilibrium, vertically below O.

Identify the statement below that correctly describes the tension, T newtons, in the string as m varies.

Tick (✓) **one** box.

[1 mark]

T varies along the string, with its greatest value at O ☐

T varies along the string, with its greatest value at P ☐

$T = 0$ because the system is in equilibrium ☐

T is directly proportional to m ☐

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
12	Ticks correct box	3.3	B1	T is directly proportional to m
	Total		**1**	

June 2019 Question 14 Paper 1

14 Two particles, A and B, lie at rest on a smooth horizontal plane.

A has position vector $\mathbf{r}_A = (13\mathbf{i} - 22\mathbf{j})$ metres
B has position vector $\mathbf{r}_B = (3\mathbf{i} + 2\mathbf{j})$ metres

14 (a) Calculate the distance between A and B.

[2 marks]

14 (b) Three forces, $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$ are applied to particle A, where

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

$$\mathbf{F}_2 = (6\mathbf{i} - 10\mathbf{j}) \text{ newtons}$$

Given that A remains at rest, explain why $\mathbf{F}_3 = (-4\mathbf{i} + 6\mathbf{j})$ newtons

[1 mark]

14 (c) A force of $(5\mathbf{i} - 12\mathbf{j})$ newtons, is applied to B, so that B moves, from rest, in a straight line towards A.

B has a mass of 0.8 kg

14 (c) (i) Show that the acceleration of B towards A is $16.25\,\text{m}\,\text{s}^{-2}$

[2 marks]

14 (c) (ii) Hence, find the time taken for B to reach A.

Give your answer to two significant figures.

[2 marks]

ANSWER

14(a)	**Condone omission of units throughout this question** Calculates the magnitude of AB Ignore one sign error.	1.1a	M1	Distance = $\sqrt{(13-3)^2+(-22-2)^2}$ = 26
	Obtains correct distance.	1.1b	A1	
14(b)	Explains that A remains at rest implies resultant force = 0 and shows $\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 = \mathbf{0}$ or shows addition of $\mathbf{F}_1$ and $\mathbf{F}_2$ and states that $\mathbf{F}_3$ is the opposite	2.4	E1	$(-2\mathbf{i}+4\mathbf{j})+(6\mathbf{i}-10\mathbf{j})=4\mathbf{i}-6\mathbf{j}$ so $\mathbf{F}_3$ is the opposite = $-4\mathbf{i}+6\mathbf{j}$
14 (c)(i)	Calculates magnitude of given force **Or** uses Newton's second law to obtain $\boldsymbol{a} = 6.25\mathbf{i} - 15\mathbf{j}$	1.1a	M1	$\lvert\boldsymbol{F}\rvert = 13$ $13 = 0.8a$ $a = 16.25$
	Completes calculation correctly AG	2.1	R1	
14 (c)(ii)	Uses appropriate suvat equation with a = 16.25 and their s used	3.3	M1	$26 = 0.5 \times 16.25 \times t^2$ $t^2 = 3.2$ $t = 1.8$
	Solves to find the correct value of time to 2sf	1.1b	A1	
	Total		**7**	

June 2019 Question 15 Paper 1

15 A tractor and its driver have a combined mass of m kilograms.

The tractor is towing a trailer of mass $4m$ kilograms in a straight line along a horizontal road.

The tractor and trailer are connected by a horizontal tow bar, modelled as a light rigid rod.

A driving force of 11 080 N and a total resistance force of 160 N act on the tractor.

A total resistance force of 600 N acts on the trailer.

The tractor and the trailer have an acceleration of $0.8\,\text{m}\,\text{s}^{-2}$

15 (a) Find m.

[3 marks]

15 (b) Find the tension in the tow bar.

[2 marks]

15 (c) At the instant the speed of the tractor reaches $18\,\text{km}\,\text{h}^{-1}$ the tow bar breaks.

The total resistance force acting on the trailer remains constant.

Starting from the instant the tow bar breaks, calculate the time taken until the speed of the trailer reduces to $9\,\text{km}\,\text{h}^{-1}$

[4 marks]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
15(a)	Models overall system as a single particle using Newton's second law, one side of equation correct. If two separate equations used, must eliminate T to obtain a single equation	3.3	M1	By $F = ma$, $11080 - 160 - 600 = 0.8(4m + m)$
	Obtains fully correct equation	1.1b	A1	$10320 = 4m$
	Obtains correct value for m	1.1b	A1	$m = 2580$
15(b)	Models either tractor or trailer separately using resistance force, T and *their* m **value**. Tractor: $11080 - 160 - T = 0.8 \times m$	3.3	M1	Trailer: $T - 600 = 0.8 \times 4 \times 2580$ $T = 8856$ newtons
	Obtains correct value for T using their m value Condone omission of units.	1.1b	A1F	

Video solution:

https://youtu.be/FDJmO3GPBrM

June 2018 Question 12 Paper 1

12 An object of mass 5 kg is moving in a straight line.

As a result of experiencing a forward force of F newtons and a resistant force of R newtons it accelerates at $0.6\,\text{m}\,\text{s}^{-2}$

Which one of the following equations is correct?

Circle your answer.

[1 mark]

$F - R = 0$ $F - R = 5$ $F - R = 3$ $F - R = 0.6$

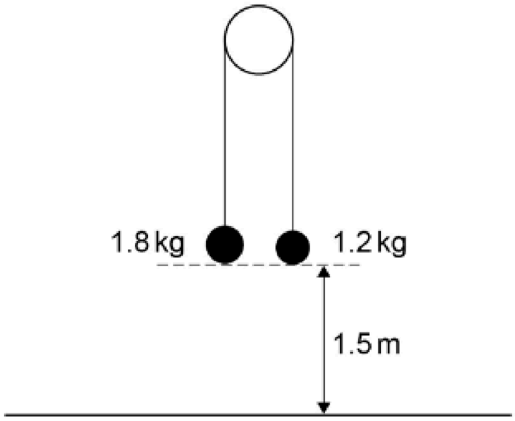
ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
12	Circles correct answer	AO2.2a	B1	$F - R = 3$
	Total		**1**	

June 2018 Question 14 Paper 1

14 **In this question use $g = 9.81\,\text{m s}^{-2}$**

Two particles, of mass 1.8 kg and 1.2 kg, are connected by a light, inextensible string over a smooth peg.



14 (a) Initially the particles are held at rest 1.5 m above horizontal ground and the string between them is taut.

The particles are released from rest.

Find the time taken for the 1.8 kg particle to reach the ground.

[5 marks]

14 (b) State one assumption you have made in answering part **(a)**.

[1 mark]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
14(a)	Forms two equations of motion for 1.8 and 1.2 kg mass, three terms, condone sign error. "Whole string" approach scores M0	AO3.4	M1	1.8 x 9.81 – T = 1.8 x a
	Obtains two correct equations	AO1.1b	A1	T – 1.2 x 9.81 = 1.2 x a
	Solves to find correct value for a 0.2g or AWRT 1.96	AO1.1b	A1	a = 1.96 m s^{-2}
	Uses $s = ut + ½\, at^2$ with *their* calculated a value	AO1.1a	M1	1.5 = ½ x 1.96 x t^2
	Calculates correct t value AWRT 1.24	AO1.1b	A1	t = 1.24 seconds
14(b)	Any valid assumption stated. Do not allow any comment already stated as an assumption in the question. Air resistance is permitted.	AO3.5b	E1	The string is long enough so that lighter mass does not reach the peg before the heavier mass hits the ground.
	Total		**6**	

June 2018 Question 15 Paper 1

15 A cyclist, Laura, is travelling in a straight line on a horizontal road at a constant speed of 25 km h^{-1}

A second cyclist, Jason, is riding closely and directly behind Laura. He is also moving with a constant speed of 25 km h^{-1}

15 (a) The driving force applied by Jason is likely to be less than the driving force applied by Laura.

Explain why.

[1 mark]

15 (b) Jason has a problem and stops, but Laura continues at the same constant speed.

Laura sees an accident 40 m ahead, so she stops pedalling and applies the brakes.

She experiences a total resistance force of 40 N

Laura and her cycle have a combined mass of 64 kg

15 (b) (i) Determine whether Laura stops before reaching the accident.

Fully justify your answer.

[4 marks]

15 (b) (ii) State one assumption you have made that could affect your answer to part **(b)(i)**.

[1 mark]

ANSWER

Q	Marking Instructions	AO	Marks	Typical Solution
15(a)	States that the resistance is less for the second rider so the force required for equilibrium is also less, or mention of slipstreaming OE	AO2.4	E1	Jason experiences less air resistance than Laura.
15(b)(i)	Models situation by using given mass and total resistance force to form equation of motion PI	AO3.3	M1	As $F = ma$ then a = - 0.625 m s^{-2}
	Uses appropriate suvat formula. May include $u = 25$.	AO3.4	M1	u = 25 km/h = 6.944 m s^{-1} v = 0; use $v^2 = u^2 + 2as$ so that 0 = 6.944^2 + 2 x (-0.625) x s
	States correct value for s (AWFW 38.5 to 38.6) **Or** maximum $u = 7.07$ m s^{-1} or 25.5 km/h (AWRT) **Or** a needs to be < -0.603 (AWRT) **Or** Resistance needs to be >38.5 N (AWFW 38.4 to 38.6) **Or** v^2 is -1.8 (AWRT) when $s = 40$	AO1.1b	A1	s = 38.6 m
	Makes appropriate comparison to conclude that Laura stops in time. Not necessary to see 38.6 < 40, but comparison for other variables must be clear.	AO3.2a	E1	So Laura stops before reaching the accident
15(b)(ii)	States an assumption that, if incorrect, would **contradict** the conclusion in **(i)**. (eg reaction time, diminishing resistive force as speed drops OE)	AO3.5a	E1F	Taking account of reaction time would mean she travelled a distance before starting to brake.
	Total		**6**	