QQQ – Mechanics Year 1 – Chapter 10 – Forces & Connected Particles (Version 1)

Total Marks: 25

(25 = Platinum, 23 = Gold, 20 = Silver, 17 = Bronze)

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1. 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 m s^{-2}

Which one of the following equations is correct?

Circle your answer. **[1 mark]**

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

(Total 1 marks)

2. Forces $\mathbf{F}_1 = (2\mathbf{i} + 9\mathbf{j})$ N and $\mathbf{F}_2 = (-\mathbf{i} + \mathbf{j})$ N act on a particle. A third force $\mathbf{F}_3$ acts so that the particle is in equilibrium under the action of the three forces.

Find the force $\mathbf{F}_3$. **[2]**

(Total 2 marks)

3. 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]**

(Total 2 marks)

4. A particle P has mass 0.25 kg.

The particle moves on a smooth horizontal surface under the action of two horizontal forces $\mathbf{F}_1$ and $\mathbf{F}_2$

Given that $\mathbf{F}_1 = (3\mathbf{i} - 5\mathbf{j})$ N and $\mathbf{F}_2 = (-6\mathbf{i} + 9\mathbf{j})$ N

(a) find, in terms of $\mathbf{i}$ and $\mathbf{j}$, the resultant force acting on P, **(1)**

(b) find the magnitude of the acceleration of P. **(3)**

A third horizontal force, $\mathbf{F}_3$, is now applied to P.

Under the action of $\mathbf{F}_1$, $\mathbf{F}_2$ and $\mathbf{F}_3$, the particle moves with constant velocity.

(c) Find $\mathbf{F}_3$, giving your answer in terms of $\mathbf{i}$ and $\mathbf{j}$. **(1)**

(Total 5 marks)

5. A tractor of mass 1800 kg uses a towbar to pull a trailer of mass 1000 kg on a level field. The tractor and trailer experience resistances to motion of 1600 N and 800 N respectively. The tractor provides a driving force of 6600 N.

(a) Draw a force diagram showing all the horizontal forces acting on the tractor and trailer. **[2]**

(b) Find the tension in the towbar. **[4]**

(Total 6 marks)

6.

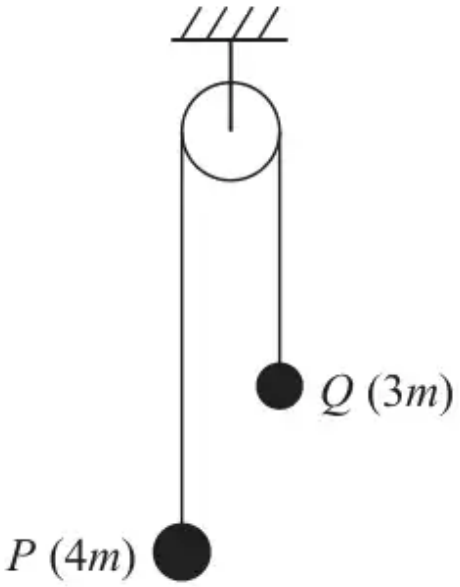


Figure 1

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)**

(b) State one limitation of the model, apart from ignoring air resistance, that will affect the accuracy of your answer to part (a). **(1)**

(Total 9 marks)

Solutions

1. AQA June 2018 Paper 1 Q12

Scheme	Marks	AO
Circles correct answer	B1	2.2a
	(1 mark)	

Typical solution

$$F - R = 3$$

2. OCR MEI October 2021 Paper 1 Q3

Scheme	Marks	AO
$\mathbf{F}_1 + \mathbf{F}_2 + \mathbf{F}_3 = \mathbf{0}$	M1	1.1a
$\mathbf{F}_3 = -(2\mathbf{i} + 9\mathbf{j} - \mathbf{i} + \mathbf{j}) = -\mathbf{i} - 10\mathbf{j}$	A1	1.1
	[2]	

Notes

M1: soi

A1: cao may be written as a column vector

3. AQA June 2025 Paper 1 Q17

Scheme	Marks	AO
Forms a three-term equation of motion Condone use of $g = 9.81$ or 10	M1	3.3
Obtains 660	A1	1.1b
	(2 marks)	

Typical solution

$$R - mg = ma$$

$$R - 60(9.8) = 60(1.2)$$

$$R = 660$$

4. Edexcel June 2025 Mechanics Q2

Mark scheme (a)

Scheme	Marks	AO
Resultant force $= (-3\mathbf{i} + 4\mathbf{j})$ (N)	B1	1.1b
	(1)	

Notes

N.B. only penalise answers given as column vectors once in this question

B1: cao. Ignore if they find the magnitude.

Mark scheme (b)

Scheme	Marks	AO
$(-3\mathbf{i} + 4\mathbf{j}) = 0.25\mathbf{a}$ **OR** $\lvert\mathbf{R}\rvert = 0.25\lvert\mathbf{a}\rvert$	M1	3.1a
$\lvert\mathbf{a}\rvert = 4\sqrt{(-3)^2 + (4)^2}$ **OR** $\lvert\mathbf{R}\rvert = \sqrt{(-3)^2 + (4)^2}$	M1	1.1b
$\lvert\mathbf{a}\rvert = 20$ $(\mathrm{m\,s^{-2}})$	A1	1.1b
	(3)	

Notes

N.B. only penalise answers given as column vectors once in this question

M1: Use of $\mathbf{R} = 0.25\mathbf{a}$ or in scalar form. Need to have used the mass correctly

M1: Use of Pythagoras on their $\mathbf{a}$ or their $\mathbf{R}$

A1: Correct only and must come from a **correct** $\mathbf{R}$.
A0 if they get 20 and then say $\lvert\mathbf{a}\rvert = \sqrt{20}$

Mark scheme (c)

Scheme	Marks	AO
$\mathbf{F}_3 = (3\mathbf{i} - 4\mathbf{j})$ (N)	B1ft	2.2a
	(1)	
	(5 marks)	

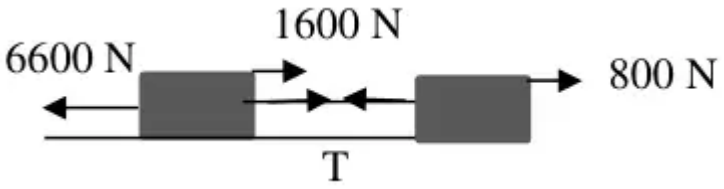
Notes

N.B. only penalise answers given as column vectors once in this question

B1ft: −(their answer to (a)) **OR** cao if they don't use answer to (a).

5. OCR MEI June 2022 Paper 1 Q9

Mark scheme (a)

Scheme	Marks	AO
Horizontal forces (could be mirror image)  	B1 B1	3.3 3.3
	[2]	

Notes

Ignore vertical forces.

B1: 6600 N and resistances correctly placed and labelled. No extra horizontal forces

B1: Common tension in the towbar shown.

Mark scheme (b)

Scheme	Marks	AO
Tractor and trailer together $6600 - 1600 - 800 = 2800a$	M1	3.1b
$a = 1.5 \text{ m s}^{-2}$	A1	1.1b
Newton's second law for the trailer $T - 800 = 1000 \times 1.5$	M1	3.1b
$T = 2300 \text{ N}$	A1	1.1b
	[4]	

Notes

M1: 2800 kg used. Allow a missing or an extra horizontal force for the method mark

A1: soi

M1: Newton's second law with correct mass. FT their acceleration. Also allow for the tractor $6600 - T - 1600 = 1800 \times 1.5$ used

A1: cao

Alternative method

Scheme	Marks	AO
Newton's second law for the tractor $6600 - T - 1600 = 1800a$ Newton's second law for the trailer $T - 800 = 1000a$	M1 A1	
Simultaneous equations	M1	
giving $T = 2300$ N	A1	

M1: Newton's second law for both parts of the system with correct masses; allow a missing or an extra horizontal force for the method mark

A1: Both equations correct

M1: Attempt to solve simultaneous equations leading to a value of T. BC means method need not be seen

A1: cao

6. Edexcel October 2020 Mechanics Q2

Mark scheme (a)

Scheme	Marks	AO
Equation of motion for P with usual rules	M1	3.3
$4mg - T = 4ma$	A1	1.1b
Equation of motion for Q with usual rules	M1	3.3
$T - 3mg = 3ma$	A1	1.1b
Solve these equations for T (does not need to be in terms of mg)	M1	1.1b
$T = \frac{24mg}{7}$ in any form (does not need to be a single term)	A1	1.1b
Force on pulley = $2T$	M1	3.4
$\frac{48mg}{7}$ Accept $6.9mg$ or better	A1	1.1b

	(8)	

Notes

M1 Translate situation into the model and set up the equation of motion for P

M0 if they omit m's i.e. $4g - T = 4a$

A1 Correct equation

M1 Translate situation into the model and set up the equation of motion for Q

M0 if they omit m's i.e. $T - 3g = 3a$

A1 Correct equation

N.B. Condone either of the above equations being replaced by the 'whole system equation':

$4mg - 3mg = 7ma$ (N.B. $a = g/7$)

N.B. a replaced by $-a$ consistently can score all the marks

M1 Solve equations for T

A1 $T = \dfrac{24mg}{7}$ oe

M1 T does not need to be substituted.

A1 $\dfrac{48mg}{7}$ oe Must be in terms of m and g and be a single term

Mark scheme (b)

Scheme	Marks	AO
Weight of the rope or extensibility of rope Or: pulley may not be smooth	B1	3.5b
	(1)	
	(9 marks)	

Notes

B1 B0 if any incorrect extras are given