QQQ – Mechanics Year 1 – Chapter 10 – Forces & Connected Particles (Version 2)

Total Marks: 24

(24 = Platinum, 22 = Gold, 19 = Silver, 16 = Bronze)

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

The total driving force is 14 N

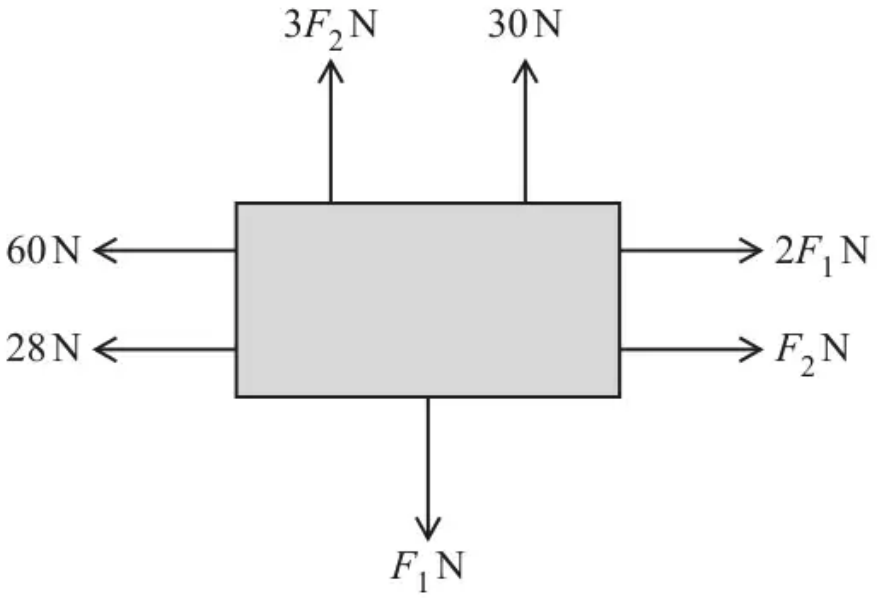
Find the total resistance force acting on the go-kart and driver.

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

- 0 N
- 3 N
- 11 N
- 14 N

(Total 1 marks)

2.



A body remains at rest when subjected to the horizontal and vertical forces shown in the diagram.

Determine the value of F_1 and the value of F_2. **[3]**

(Total 3 marks)

3. A particle is in equilibrium under the action of the following three forces:

$(2p\mathbf{i} - 4\mathbf{j})$ N, $(-3q\mathbf{i} + 5p\mathbf{j})$ N and $(-13\mathbf{i} - 6\mathbf{j})$ N.

Find the values of p and q. **[3]**

(Total 3 marks)

4. A particle P lies at rest on a smooth horizontal table.

A constant resultant force, $\mathbf{F}$ newtons, is then applied to P.

As a result P moves in a straight line with constant acceleration $\begin{bmatrix} 8 \\ 6 \end{bmatrix}$ m s^{-2}

(a) Show that the magnitude of the acceleration of P is 10 m s^{-2} **[1 mark]**

(b) Find the speed of P after 3 seconds. **[1 mark]**

(c) Given that $\mathbf{F} = \begin{bmatrix} 2 \\ 1.5 \end{bmatrix}$ N, find the mass of P. **[2 marks]**

(Total 4 marks)

5. Two blocks A and B have masses 5 kg and 2 kg respectively. The blocks are joined together by a light rigid horizontal bar and slide across a horizontal surface. The resistances on the blocks A and B are modelled as 7 N and 1.75 N respectively. There are no other external horizontal forces.

(a) Calculate the acceleration of the system, according to the model. **[3]**

(b) In reality, the acceleration of the system is **not** constant. State an improvement that could be made to the model so that it will produce results which are closer to the real situation. **[1]**

(Total 4 marks)

6.

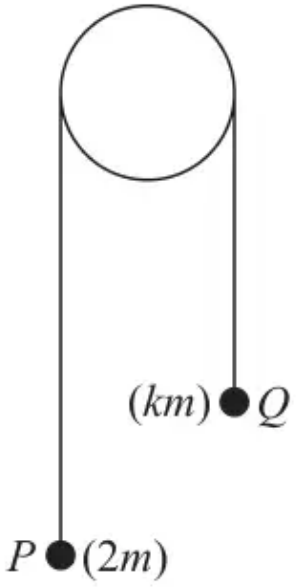


Figure 1

Two small balls, P and Q, have masses $2m$ and km respectively, where $k < 2$.
The balls are attached to the ends of a string that passes over a fixed pulley.
The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 1.

The system is released from rest and, in the subsequent motion, P moves downwards with an acceleration of magnitude $\frac{5g}{7}$

The balls are modelled as particles moving freely.
The string is modelled as being light and inextensible.
The pulley is modelled as being small and smooth.

Using the model,

(a) find, in terms of m and g, the tension in the string, **(3)**

(b) explain why the acceleration of Q also has magnitude $\frac{5g}{7}$ **(1)**

(c) find the value of k. **(4)**

(d) Identify one limitation of the model that will affect the accuracy of your answer to part (c).
(1)

(Total 9 marks)

Solutions

1. AQA June 2020 Paper 1 Q11

Scheme	Marks	AO
Circles correct answer	B1	1.1b
	(1 mark)	

Typical solution

3 N

2. OCR A October 2021 Paper 2 Q9

Scheme	Marks	AO
$R(\uparrow): 3F_2 + 30 = F_1$	M1	3.4
$R(\rightarrow): 2F_1 + F_2 = 60 + 28$	A1	1.1
$F_1 = 42,\ F_2 = 4$	A1	1.1
	[3]	

Notes

M1: Attempt to resolve vertically and horizontally with at least one correct equation seen

A1: Both equations correct

A1: BC

3. OCR A October 2020 Paper 2 Q8

Scheme	Marks	AO
$-4 + 5p - 6 = 0 \Rightarrow p = 2$	B1	1.1
$2p - 3q - 13 = 0$ and $p = 2 \Rightarrow q = \ldots$	M1	1.1
$q = -3$	A1	1.1
	[3]	

Notes

B1: Correct value $p = 2$ stated

M1: Equating **i**-components to zero and using their numerical p to find q

4. AQA June 2021 Paper 1 Q12

Mark scheme (a)

Scheme	Marks	AO
Uses Pythagoras to show given magnitude AG	B1	1.1b
	(1)	

Typical solution

$$\sqrt{8^2 + 6^2} = 10$$

Mark scheme (b)

Scheme	Marks	AO
Uses appropriate suvat equation with given values to find correct speed value condone missing units	B1	1.1b
	(1)	

Typical solution

$$u = 0,\ a = 10,\ t = 3$$

so

$$v = 0 + (3)(10) = 30 \text{ m s}^{-1}$$

Mark scheme (c)

Scheme	Marks	AO
Uses $F = ma$, using magnitude of force with magnitude of acceleration or in vector form PI by correct answer	M1	3.4
Finds correct mass condone missing units	A1	1.1b
	(2)	
	(4 marks)	

Typical solution

$$\sqrt{2^2 + 1.5^2} = 2.5$$

$$2.5 = m \times 10$$

$$m = 0.25 \text{ kg}$$

5. OCR MEI June 2025 Paper 1 Q5

Mark scheme (a)

Scheme	Marks	AO
$-7 - 1.75 = (5 + 2)a$	M1 A1	1.1a 1.1
$a = -\frac{8.75}{7} = -1.25 \text{ ms}^{-2}$	A1	1.1
	[3]	

Notes

M1: Uses the combined mass in N2L equation. Allow sign errors. No extra forces. Do not allow for mga.

A1: Correct equation Also allow $8.75 = 7a$ soi.

A1: Cao. Negativity must follow from their working, or clearly states deceleration of 1.25 ms^{-2}

Alternative method

Scheme	Marks	AO
For 5kg block $T - 7 = 5a$ For 2kg block $-T - 1.75 = 2a$	M1	
$-7 - 1.75 = (5 + 2)a$	A1	
$a = -\frac{8.75}{7} = -1.25 \text{ ms}^{-2}$	A1	

M1: Sets up an equation for each block including Tension. Allow sign errors. No extra forces. Do not allow for mga.

A1: Correct equation with T eliminated. Any form.
Also allow $8.75 = 7a$ soi.

A1: Cao. Negativity must follow from their working, or clearly states deceleration of 1.25 ms^{-2}

Mark scheme (b)

Scheme	Marks	AO
Model the resistance with a variable force	B1	3.5c
	[1]	

Notes

B1: Allow a particular example of a variable force or variation in some other factor

6. Edexcel June 2018 Mechanics Q9

Mark scheme (a)

Scheme	Marks	AO
Equation of motion for P	M1	3.3
$2mg - T = 2m \times \frac{5g}{7}$	A1	1.1b
$T = \frac{4mg}{7}$	A1	1.1b
	(3)	

Notes

Condone both equations of motion appearing in (a) if used in (c)

M1: Resolving vertically for P with usual rules, correct no. of terms but condone sign errors and a does not need to be substituted (N.B. inconsistent omission of m is M0). Allow ma on RHS for M1

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

A1: A correct answer of form cmg, where $c = \frac{4}{7}$ oe or 0.57 or better

Mark scheme (b)

Scheme	Marks	AO
Since the string is modelled as being inextensible	B1	3.4
	(1)	

Notes

B1: String is inextensible. N.B. B0 if any extras (wrong or irrelevant) given

Mark scheme (c)

Scheme	Marks	AO
Equation of motion for Q **OR** for whole system	M1	3.3
$T - kmg = km \times \frac{5g}{7}$ **OR** $2mg - kmg = (km + 2m)\frac{5g}{7}$	A1	1.1b
$\frac{4mg}{7} - kmg = km \times \frac{5g}{7}$ oe and solve for k	DM1	1.1b
$k = \frac{1}{3}$ or 0.333 or better	A1	1.1b
	(4)	

Notes

Condone both equations of motion appearing in (a) if used in (c)

M1: Resolving vertically for Q or for a whole system equation, with usual rules, correct no. of terms but condone sign errors and neither T nor a does need to be substituted

(N.B. inconsistent omission of m is M0 and M0 if k is omitted from LHS or RHS or both.)

A1: A correct equation (allow if they use 7 instead of $\frac{5g}{7}$)

DM1: Sub for T using their answer from (a), if necessary, and solve to give a numerical value of k (i.e. m's must cancel)

A1: $k = \frac{1}{3}$ or 0.333 or better.

Mark scheme (d)

Scheme	Marks	AO
e.g The model does not take account of the mass of the string (SEE BELOW for alternatives)	B1	3.5b
	(1)	
	(9 marks)	

Notes

B1: e.g. Pulley may not be smooth
Pulley may not be light
Particles may not be moving freely e.g. air resistance
Balls may not be particles

String may not be light

String may not be inextensible

(but allow converses in all cases e.g. 'pulley smooth')

N.B. B0 if any extra incorrect answer is given BUT ignore incorrect consequence of a correct answer.

Also note: B0 : Use of a more accurate value of g