2021 ASSESSMENT MATERIALS

AS
MATHS
Mechanics

Total number of marks:39

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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.

$14 - R = 55 \times 0.2$

$R = 3$

[1 mark]

0 N 3 N 11 N 14 N

11 A ball moves in a straight line and passes through two fixed points, A and B, which are 0.5 m apart.

The ball is moving with a constant acceleration of $0.39\,\mathrm{m\,s^{-2}}$ in the direction AB.

The speed of the ball at A is $1.9\,\mathrm{m\,s^{-1}}$

Find the speed of the ball at B.

Circle your answer.

$S = 0.5$
$U = 1.9$
V
$A = 0.39$
T

$V^2 = U^2 + 2as$

$V = 2$

[1 mark]

$2\,\mathrm{m\,s^{-1}}$ $3.2\,\mathrm{m\,s^{-1}}$ $3.8\,\mathrm{m\,s^{-1}}$ $4\,\mathrm{m\,s^{-1}}$

12 One of the following is an expression for the distance between the points represented by position vectors $5\mathbf{i} - 3\mathbf{j}$ and $18\mathbf{i} + 7\mathbf{j}$

Identify the correct expression.

Tick (✓) **one** box.

[1 mark]

$\sqrt{13^2 + 4^2}$ ☐

$\sqrt{13^2 + 10^2}$ ☑

$\sqrt{23^2 + 4^2}$ ☐

$\sqrt{23^2 + 10^2}$ ☐

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 ☑

$T = mg$

$T \propto m$

13 A vehicle, which begins at rest at point P, is travelling in a straight line.

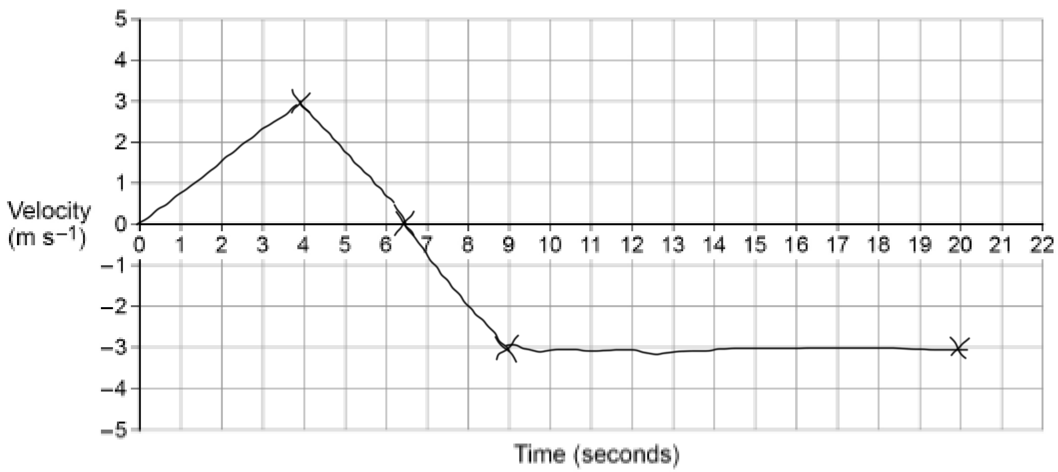
For the first 4 seconds the vehicle moves with a constant acceleration of $0.75\ \text{m s}^{-2}$ $V = U + at$
$V = 3$

For the next 5 seconds the vehicle moves with a constant acceleration of $-1.2\ \text{m s}^{-2}$ $V = U + at$
$V = -3$

The vehicle then immediately stops accelerating, and travels a further 33 m at constant speed. $\frac{33}{3} = t = 11$

13 (a) Draw a velocity–time graph for this journey on the grid below.

[3 marks]



13 (b) Find the distance of the car from P after 20 seconds.

[3 marks]

$V = +$ $\quad 0 - 6.5 = \frac{1}{2} \times 6.5 \times 3 = 9.75$

$V = -$ $\quad 6.5 - 9 = 0.5 \times 2.5 \times 3 = 3.75$

$V = -$ $\quad 9 - 20 = 33$

$V_- - V_+ = 33 + 3.75 - 9.75 = 27\text{m}$

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 $4\,\mathrm{m\,s^{-1}}$ after travelling a distance of 3.2 m

Find **F**.

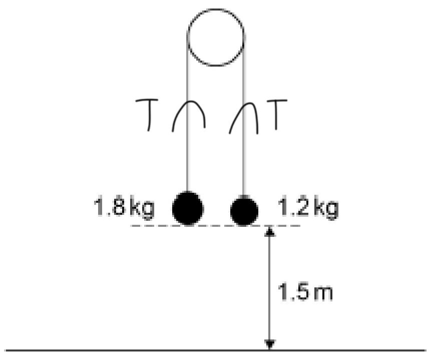
[5 marks]

$S=3.2$
$U=0$
$V=4$
$A=?$
T

$V^2=U^2+2AS$
$A=2.5$
$F=2.5\times 0.1$
$=0.25\text{ N}$

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

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



$1.8g-T=1.8a$
$T-1.2g=1.2a$
$0.6g=3a$
$a=1.96$

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]

$S=1.5$
$U=0$
V
$A=1.96$
$T=?$
$S=ut+\frac{1}{2}at^2$
$t=1.237$
$=1.24$

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

[1 mark]

No air resistance

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]

$|\overrightarrow{AB}| = \sqrt{10^2+24^2} = 26$

$\overrightarrow{AB}$
$-10i+24j$

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]

as the resultant force $= 0$

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 $16.25\,\text{m s}^{-2}$

[2 marks]

$F = ma$

$a = \left|\begin{pmatrix}5\\12\end{pmatrix} \times \frac{1}{0.8}\right| = \frac{\sqrt{5^2+12^2}}{0.8} = 16.25\,\text{ms}^{-2}$

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

Give your answer to two significant figures.

[2 marks]

$S = 26$ $\quad S = ut + \frac{at^2}{2}$

$U = 0$ $\quad t^2 = 3.2$

V

$A = 16.25$ $\quad t = 1.79$

T $\quad = 1.8$

13 A car, starting from rest, is driven along a horizontal track.

The velocity of the car, $v\,\text{m s}^{-1}$, at time t seconds, is modelled by the equation

$$v = 0.48t^2 - 0.024t^3 \text{ for } 0 \le t \le 15$$

13 (a) Find the distance the car travels during the first 10 seconds of its journey.

[3 marks]

$\int_0^{10} V\,dt = \left[\frac{0.48}{3}t^3 - \frac{0.024}{4}t^4\right]_0^{10} = 100$

13 (b) Find the maximum speed of the car.

Give your answer to three significant figures.

[4 marks]

$\frac{dV}{dt} = 0 = 0.96t - 0.072t^2$ $\quad t = \frac{40}{3}$ $\quad V$ at $t = \frac{40}{3}$ is $28.4\,\text{ms}^{-1}$

13 (c) Deduce the range of values of t for which the car is modelled as decelerating.

[2 marks]

Speed increasing until $t = \frac{40}{3}$

$\therefore \frac{40}{3} < t \leq 15$

15 A particle, P, is moving in a straight line with acceleration $a\,\text{m}\,\text{s}^{-2}$ at time t seconds, where

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

15 (a) Initially P is stationary.

Find an expression for the velocity of P in terms of t.

[2 marks]

$V = \int a\,dt$

$V = 4t - t^3 + C$

$v = 0$ at $t = 0$ $\therefore C = 0$

$V = 4t - t^3$