Question 1

(a) **What is the shortest stopping time for a car which is travelling at 16 m s^{-1} and has a maximum deceleration of 2.5 m s^{-2}?**

$v = u + at$ / $s = ut + \frac{1}{2}at^2$ / $v^2 = u^2 + 2as$ 4

$t = 6.4$ s *(–1 for omission of or incorrect units)* 3

Each question carries 40 marks.

Question 1

In an experiment to investigate the relationship between the acceleration of a body and the force applied to it, a student recorded the following data.

F/N	0.20	0.40	0.60	0.80	1.00	1.20	1.40
a/m s^{-2}	0.08	0.18	0.28	0.31	0.45	0.51	0.60

Describe the steps involved in measuring the acceleration of the body.

measure/calculate the initial velocity/speed 3
measure/calculate the velocity/speed again (t seconds later) 3
measure time interval from initial to final velocities / distance between light gates 3
use relevant formula e.g. $v = u + at$ / $v^2 = u^2 + 2as$ 3

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Datalogging method:
align motion sensor with body (e.g. trolley) / diagram (3)
select START and release body (3)
(select STOP and) display GRAPH of 'a vs. t' // 'v vs. t' (3)
(use tool bar to) find average value for a // use slope (tool) to find a $(=\frac{dv}{dt})$ (3)

Using the recorded data, plot a graph to show the relationship between the acceleration of the body and the force applied to it. What does your graph tell you about this relationship?

label axes correctly on graph paper 3
plot six points correctly **(–1 per each incorrect/omitted point)** 3
straight line 3
good distribution 3
correct statement / correct equation / $a \alpha F$ 4

16

Using your graph, find the mass of the body.

correct method for slope 3
(m =) 2.32 kg [range: 2.1 ↔ 2.4 kg] 3
(–1 for omission of or incorrect units)

6

On a trial run of this experiment, a student found that the graph did not go through the origin. Suggest a reason for this and describe how the apparatus should be adjusted, so that the graph would go through the origin.

friction / any valid reason 3
elevate/adjust the track/slope 3

6

Question 1

In an experiment to measure the acceleration due to gravity, the time *t* for an object to fall from rest through a distance *s* was measured. The procedure was repeated for a series of values of the distance *s*. The table shows the recorded data.

s/m	0.30	0.50	0.70	0.90	1.10	1.30	1.50
t/s	0.247	0.310	0.377	0.435	0.473	0.514	0.540
t^2/s^2	0.0610	0.0961	0.1421	0.1892	0.2237	0.2642	0.2916

Draw a labelled diagram of the apparatus used in the experiment .
timer, ball, release mechanism, pressure plate/trap door (any two items for 3 marks) 3+2+1
(–1 if release mechanism not labelled)

Indicate the distance *s* on your diagram.
(perpendicular) distance indicated between bottom of ball and top of pressure plate
(any correct answer) 3

Describe how the time interval *t* was measured.
timer starts when ball leaves release mechanism 3
timer stops when ball hits pressure plate/trap door/ impact switch 3

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Calculate a value for the acceleration due to gravity by drawing a suitable graph based on the recorded data.

at least 6 correct values for t^2 **(–1 per each incorrect value)** 3
axes correctly labelled 3
at least 6 points correctly plotted 3
straight line with a good distribution **(–1 for poor distribution)** 3
correct slope method 3
slope = 5.02 // 0.198 (≈ 0.20) 3
g = (10.04 ± 0.20) m s^{-2} **(–1 for omission of or incorrect unit)** 3

21

Give two ways of minimising the effect of air resistance in the expe riment.

small(object)/ smooth(object)/ no draughts/ in vacuum/ distances relatively short
heavy (object) / dense / spherical/ aerodynamic 2+2

4

Question 6

State Newton's laws of motion.

- body <u>at rest</u>/<u>moves with constant velocity</u> unless external force acts — 3
- force proportional to // $F \propto$ — 3
  rate of change of momentum // $\frac{\Delta p}{\Delta t}$ — 3
  ($F = ma$ .... 3 marks)
- action and reaction are equal and opposite — 3

12

Show that $F = ma$ is a special case of Newton's second law.

$F \propto \frac{mv - mu}{t}$ — 3

$F \propto ma$ — 3

$F = kma$ — 3

$k = 1$ — 1

10

A skateboarder with a total mass of 70 kg starts from rest at the top of a ramp and accelerates down it. The ramp is 25 m long and is at an angle of 20° to the horizontal. The skateboarder has a velocity of 12.2 m s^{-1} at the bottom of the ramp.

Calculate :

(i) the average acceleration of the skateboarder on the ramp.

$v^2 = u^2 + 2as$ // $(12.2)^2 = 0 + 2a(25)$ — 3

$a = 2.977$ m s^{-2} (≈ 2.98 m s^{-2}) **(–1 for omission of or incorrect unit)** — 3

(ii) the component of the skateboarder's weight that is parallel to the ramp.

$(W =)$ $mg\sin\theta$ / $mg\cos\theta$ / $mg\sin 20$ / $mg\cos 70$ — 3

$(W =)$ 234.63 N **(–1 for omission of *g*)** — 3

(–1 for omission of or incorrect unit)

(iii) the force of friction acting on the skateboarder on the ramp.

$F_r = 234.63 - 70(2.977)$ // $F_r = 234.63 - 208.38$ N — 3

$F_r = 26.25$ N

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The skateboarder then maintains a speed of 10.5 m s^{-1} until he enters a circular ramp of radius 10 m. What is the initial centripetal force acting on him?

$F = \frac{mv^2}{r}$ // $F = \frac{70(10.5)^2}{10}$ — 3

$F = 771.75$ N **[–1 for omission of or incorrect unit if not already penalised in (ii)]** — 3

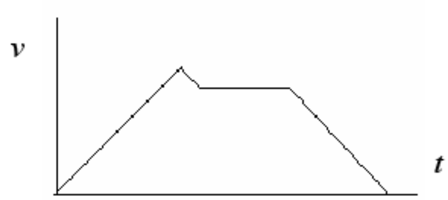
What is the maximum height that the skateboarder can reach?

$v^2 = u^2 + 2as$ // $u^2 = 2gs$ // $E_k = E_p$ // $\frac{1}{2}mv^2 = mgh$ // $h = \frac{u^2}{2g}$ — 3

$0 = (10.5)^2 + 2(-9.8)h$ // $h = \frac{(10.5)^2}{2(9.8)}$ // $h = 5.63$ m **(–1 for omission of or incorrect unit)** — 3

12

Sketch a velocity-time graph to illustrate his motion.



any line/curve from origin — 3

correct graph shape — 1

(–1 if no spike)

4

Question 5

(i) What is the angular velocity of the hammer during its final swing?

$T = \frac{2\pi}{\omega}$ 3

$\omega = \frac{2\pi}{0.8}$ / 7.8(54) s^{-1} **(−1 for omission of or incorrect units)** 3

(ii) Even though the hammer moves at a constant speed, it accelerates. Explain.

direction changes (continuously) 4

Calculate

(iii) the acceleration of the hammer during its final swing

$a = \omega^2 r$ 3

$= (7.854)^2(2)$ 3

acceleration = 123.37 m s^{-2} , towards the centre (of orbit) / inwards **(−1 if no direction given)** 3

(−1 for omission of or incorrect units)

(iv) the kinetic energy of the hammer as it is released.

K.E = $\frac{1}{2} m v^2$ 3

$= \frac{1}{2} m(\omega r)^2$ / $\frac{1}{2}(7.26)(15.71)^2$ 3

K.E = 896 J **(−1 for omission of or incorrect units)** 3