Mr Cowen's answers

THIS IS A NEW SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

Mock

PHYSICS A **G481**

Mechanics

Thursday 21 May 2009
Afternoon

Duration: 1 hour

Candidates answer on the question paper

OCR Supplied Materials:
- Formulae, Data and Relationships Booklet

Other Materials Required:
- Electronic calculator
- Ruler
- Protractor

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **60**.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example, you should
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- You may use an electronic calculator.
- This document consists of **16** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	6	
2	7	
3	9	
4	11	
5	11	
6	5	
7	11	
TOTAL	**60**	

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Turn over

Answer **all** the questions.

1 **(a)** State a similarity and a difference between *distance* and *displacement*.

(i) similarity: Measured in metres. [1]

(ii) difference: Distance is a scalar, displacement is a vector. [1]

(b) Fig. 1.1 shows two airports **A** and **C**.

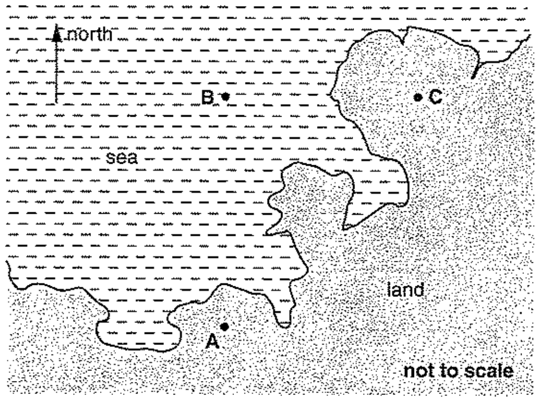


Fig. 1.1

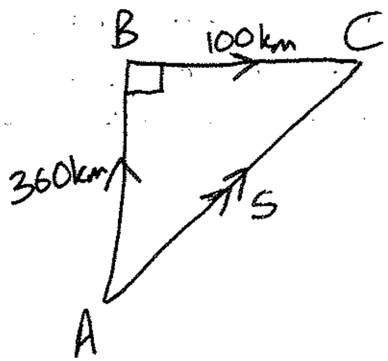
An aircraft flies due north from **A** for a distance of 360 km (3.6×10^5 m) to point **B**. Its average speed between **A** and **B** is $170\,\mathrm{m\,s^{-1}}$. At **B** the aircraft is forced to change course and flies due east for a distance of 100 km to arrive at **C**.

(i) Calculate the time of the journey from **A** to **B**.

$$v = \frac{s}{t} \quad t = \frac{s}{v} = \frac{360\times10^3}{170} = 2120\,s$$

time = 2120 s [1]

(ii) Draw a labelled displacement vector triangle below. Use it to determine the magnitude of the displacement in km of the aircraft at **C** from **A**.



$AC = \sqrt{360^2 + 100^2}$

$= 374$ km

displacement = 374 km **[3]**

[Total: 6]

2 Fig. 2.1 shows a graph of velocity against time for an object travelling in a straight line.

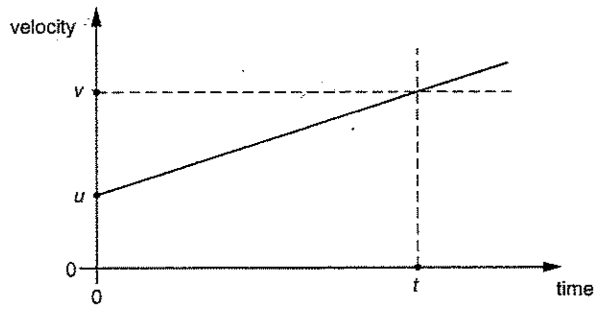


Fig. 2.1

The object has a constant acceleration *a*. In a time *t* its velocity increases from *u* to *v*.

(a) Describe how the graph of Fig. 2.1 can be used to determine

(i) the acceleration *a* of the object

In your answer, you should use appropriate technical terms, spelled correctly.

Find the gradient of the line

$\frac{(v-u)}{t} = a$ **[1]**

(ii) the displacement *s* of the object.

Find the area under the graph.

[1]

(b) Use the graph of Fig. 2.1 to show that the displacement s of the object is given by the equation:

$$s = ut + \frac{1}{2}at^2$$

area of rectangle

area of triangle

$$\text{Area} = ut + \frac{(v-u)t}{2}$$

~~Area of a trapezium~~

~~Area = vt − ½(v−u)t~~

$$\frac{v-u}{t} = a$$

$$v - u = at$$

$$\text{Area} = s = ut + \frac{1}{2}(at)t$$

$$s = ut + \frac{1}{2}at^2$$

[2]

(c) In order to estimate the acceleration g of free fall, a student drops a large stone from a tall building. The height of the building is known to be 32 m. Using a stopwatch, the time taken for the stone to fall to the ground is 2.8 s.

(i) Use this information to determine the acceleration of free fall.

$a = ?,\ u = 0,\ t = 2.8,\ s = 32$

$s = \cancel{ut} + \frac{1}{2}at^2 = \frac{1}{2}at^2$

$a = \frac{2s}{t^2} = \frac{2 \times 32}{2.8^2} = 8.16\ \text{ms}^{-2}$

acceleration = 8.16 m s^{-2} [2]

(ii) One possible reason why your answer to **(c)(i)** is smaller than the accepted value of $9.81\ \text{m s}^{-2}$ is the reaction time of the student. State another reason why the answer is smaller than $9.81\ \text{m s}^{-2}$.

Air resistance acts on the stone.

[1]

[Total: 7]

3 A skydiver jumps from a stationary hot-air balloon several kilometres above the ground.

(a) In terms of acceleration and forces, explain the motion of the skydiver

immediately after jumping Acceleration = g = $9.81\ \text{ms}^{-2}$

The only force acting is ~~gravity~~ weight (mg) as air resistance is zero due to his velocity being zero.

at a time **before** terminal velocity is reached Acceleration is less than $9.81\ \text{ms}^{-2}$, but greater than 0. The weight of the skydiver is greater than the ~~air r~~ drag, so there is a net force downwards.

Drag increases with speed^2

at terminal velocity. Acceleration is zero - travelling at a constant velocity. Weight = drag.

[6]

(b) In the final stage of the fall, the skydiver is falling through air at a constant speed. The skydiver's kinetic energy does not change even though there is a decrease in the gravitational potential energy. State what happens to this loss of gravitational potential energy.

Air resistance causes this to be converted to heat. [1]

(c) Fig. 3.1 shows a sketch graph of the variation of the velocity v of the skydiver with time t.

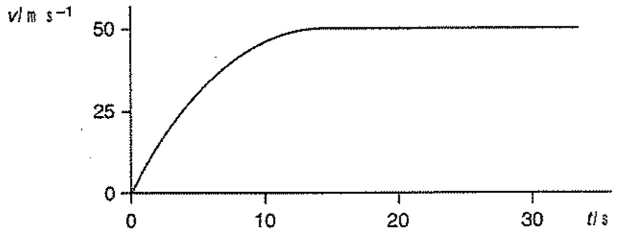


Fig. 3.1

Suggest the changes to the graph of Fig. 3.1, if any, for a more massive (heavier) skydiver of the same shape.

The terminal velocity will be higher ~~as~~ because the air resistance ~~will~~ must counter a higher weight. ~~The initial ex curve between 0 and 10s will be steeper.~~ [2]

Time taken to reach terminal V is longer.

[Total: 9]

4 (a) Define *work done* by a force.

~~Energy req~~ Work done = force × distance moved in direction of force. [2]

(b) Define *power*.

Rate of change of energy = $\frac{\text{energy or work}}{\text{time}}$ [1]

(c) Explain why the efficiency of a mechanical device can never be 100%.

Some energy will always be dissipated as heat due to friction. [1]

(d) A car has a total mass of 810 kg. Its speed changes from zero to 30 m s⁻¹ in a time of 12 s.

(i) Calculate the change in the kinetic energy of the car.

$t = 0, \quad E_K = 0$

$t = 12, \quad E_K = \frac{1}{2}mv^2 = \frac{1}{2} \times 810 \times 30^2$

$= 365\,kJ$

change in kinetic energy = 365 kJ J [2]

(ii) Calculate the average power generated by the car engine. Assume that the power generated by the engine of the car is entirely used in increasing the kinetic energy of the car.

$$P = \frac{E_K}{t} = \frac{365}{12} = 30.4\,kW$$

power = 30.4 kW W [1]

(iii) The actual efficiency of the car is 25%. The car takes 18 kg of petrol to fill its tank. The energy provided per kilogram of petrol is 46 MJ kg^{-1}. The drag force acting on the car at a constant speed of 30 m s^{-1} is 500 N.

1 Calculate the work done against the drag force per second.

$$\frac{W}{t} = \frac{Fx}{t} = Fv = 500 \times 30 = 15000\ \mathrm{J\,s^{-1}}$$

work done per second = 1.5×10^4 J s^{-1} [1]

2 Calculate the total distance the car can travel on a full tank of petrol when travelling at a constant speed of 30 m s^{-1}.

Energy in one tank = 18×46

= 828 MJ

$$t = \frac{828 \times 10^6}{1.5 \times 10^4} \cancel{\div 55200} \times 0.25 = 13800\ \mathrm{s}$$

$v = \frac{s}{t}$ $s = vt = 30 \times 13800 = 414000$

distance = 414000 m [3]

[Total: 11]

5 (a) Fig. 5.1 shows a wooden block motionless on an inclined ramp.

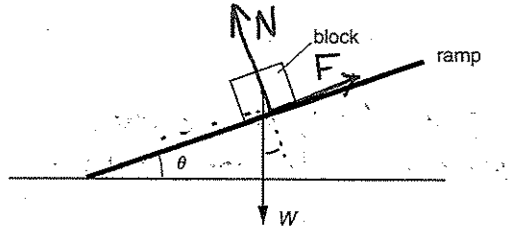


Fig. 5.1

The angle between the ramp and the horizontal is θ.

(i) The weight W of the block is already shown on Fig. 5.1. Complete the diagram by showing the normal contact (reaction) force N and the frictional force F acting on the block. [2]

(ii) Write an equation to show how F is related to W and θ.

$F = W \sin\theta$

[1]

(b) Fig. 5.2 shows a kitchen cupboard securely mounted to a vertical wall. The cupboard rests on a support at **A**.

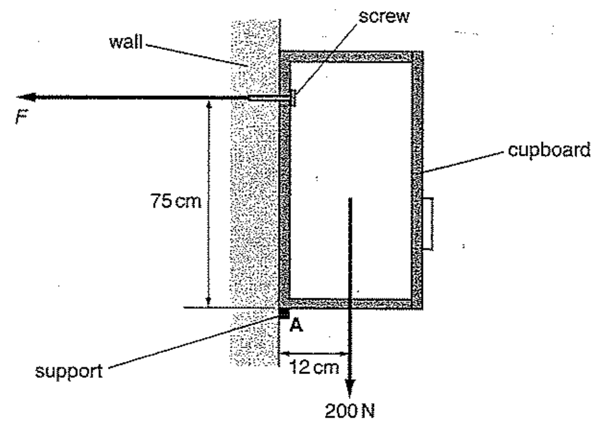


Fig. 5.2

The total weight of the cupboard and its contents is 200 N. The line of action of its weight is at a distance of 12 cm from **A**. The screw securing the cupboard to the wall is at a vertical distance of 75 cm from **A**.

(i) State the principle of moments.

In your answer, you should use appropriate technical terms, spelled correctly.

Sum of clockwise moments is equal to the sum of anticlockwise moments around the same point. [2]

(ii) The direction of the force F provided by the screw on the cupboard is horizontal as shown in Fig. 5.2. Take moments about **A**. Determine the value of F.

$$\circlearrowright = \circlearrowleft \quad 200 \times 0.12 = F \times 0.75$$

$$F = \frac{200 \times 0.12}{0.75} = 32$$

$F =$ 32 N [2]

(iii) The cross-sectional area under the head of the screw in contact with the cupboard is $6.0 \times 10^{-5}\,m^2$. Calculate the pressure on the cupboard under the screw head.

$$p = \frac{F}{A} = \frac{32}{6 \times 10^{-5}} = 533\,kPa$$

pressure = 533 kPa Pa [2]

(iv) State and explain how your answer to **(iii)** would change, if at all, if the same screw was secured much closer to **A**.

If F was acting closer to A it would require a larger force to provide the same moment, so the pressure would increase. [2]

[Total: 11]

Turn over

6 In February 1999 NASA launched its Stardust spacecraft on a mission to collect dust particles from the comet Tempel 1. After a journey of 5.0×10^{12} m that took 6.9 years, Stardust returned to Earth with samples of the dust particles embedded in a special low-density gel. When a dust particle hits the gel, it buries itself in the gel creating a cone-shaped track as shown in Fig. 6.1. The length of the track is typically 200 times the diameter of the dust particle.

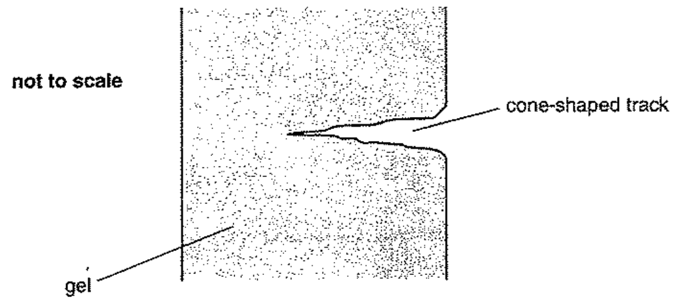


Fig. 6.1

(a) Calculate the average speed in $m\,s^{-1}$ of Stardust during its voyage.

$$v = \frac{s}{t} = \frac{5 \times 10^{12}}{6.9 \times 3.16 \times 10^{7}} = 22.9 \times 10^{3}$$

speed = 22.9×10^{3} $m\,s^{-1}$ [2]

(b) Calculate the average stopping force produced by the gel for a dust particle of diameter 0.70 mm and mass 4.0×10^{-6} kg travelling at a velocity of $6.1 \times 10^{3}\,m\,s^{-1}$ relative to Stardust.

$$s = 200 \times 0.7 \times 10^{-3} = 0.14\,m$$

~~a = v/t~~ $\quad u = 6.1 \times 10^{3} \quad a = ?$

$v = 0$

$$v^2 = u^2 + 2as$$

$$a = \frac{v^2 - u^2}{2s} = \frac{0 - (6.1 \times 10^{3})^2}{2 \times 0.14} = \cancel{-21.8 \times 10^{3}\,ms^{-1}} \quad 133 \times 10^{6}\,ms^{-2}$$

force = ~~0.087~~ 532 N [3]

~~$F = ma = 4 \times 10^{-6} \times 21.8 \times 10^{3}$~~

$$F = ma = 4 \times 10^{-6} \times 133 \times 10^{6} = 532\,N$$

[Total: 5]

7 **(a)** On the axes of Fig. 7.1, sketch a stress against strain graph for a typical ductile material.

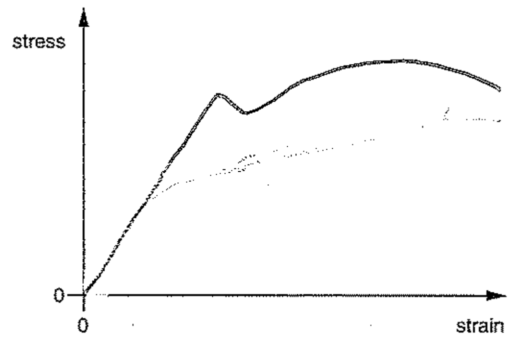


Fig. 7.1

[2]

(b) Circle from the list below a material that is ductile.

jelly copper ceramic glass [1]

(c) Define *ultimate tensile strength* of a material.

The stress at which a material will break [1]

(d) State *Hooke's law.*

Force $\propto$ extension

[1]

(e) Fig. 7.2 shows a mechanism for firing a table tennis ball vertically into the air.

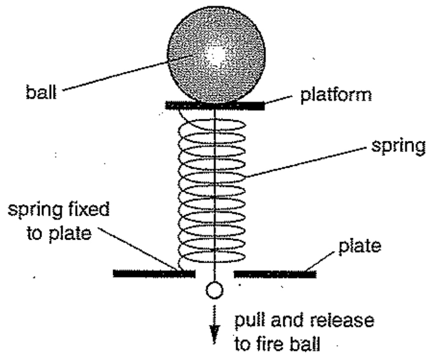


Fig. 7.2

The spring has a force constant of $75\,N\,m^{-1}$. The ball is placed on the platform at the top of the spring.

(i) The spring is compressed by 0.085 m by pulling the platform. Calculate the force exerted by the compressed spring on the ball **immediately** after the spring is released. Assume both the spring and the platform have negligible mass.

$F = kx = 75 \times 0.085 = 6.38\,N$

force = 6.38 N [2]

(ii) The mass of the ball is 2.5×10^{-3} kg. Calculate the initial acceleration of the ball.

$F = ma$

$a = \frac{F}{m} = \frac{6.38}{2.5 \times 10^{-3}} = 2550\,ms^{-2}$

acceleration = 2550. ms^{-2} [1]

(iii) Calculate the maximum height that could be gained by the ball. Assume all the elastic potential energy of the spring is converted into gravitational potential energy of the ball.

$$E = \frac{1}{2}kx^2 = \frac{1}{2} \times 75 \times 0.085^2$$

$$= 0.270\ J$$

$$E_p = mgh = 0.270$$

$$h = \frac{0.270}{mg} = \frac{0.270}{2.5\times10^{-3}\times9.81} = 11.0$$

height = 11.0 m **[3]**

[Total: 11]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE