OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A 2821

Forces and Motion

Monday **14 JANUARY 2002** Morning 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler
Protractor

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu	Max.	Mark
1	14	
2	6	
3	12	
4	8	
5	16	
6	7	
7	9	
8	14	
QWC	4	
TOTAL	90	

This question paper consists of 16 printed pages.

Registered Charity Number:1066969
[Turn over

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	$R = 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall,	$g = 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$

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

refractive index, $n = \frac{1}{\sin C}$

capacitors in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

capacitor discharge, $x = x_0 e^{-t/CR}$

pressure of an ideal gas, $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

radioactive decay, $x = x_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

relativity factor, $= \sqrt{(1 - \frac{v^2}{c^2})}$

current, $I = nAve$

nuclear radius, $r = r_0 A^{1/3}$

sound intensity level, $= 10 \lg \left(\frac{I}{I_0}\right)$

Answer **all** the questions.

1 **(a)** **(i)** Define *speed.*

.....

.....

(ii) Define *velocity.*

.....

.....

(iii) State and explain the differences between these quantities.

.....

.....

.....

[4]

(b) Fig. 1.1 shows a fairground big wheel. The wheel is rotating in a vertical plane and carriages travel round a circle of diameter 40 m at a constant speed. The carriages complete one revolution in 3.5 minutes.

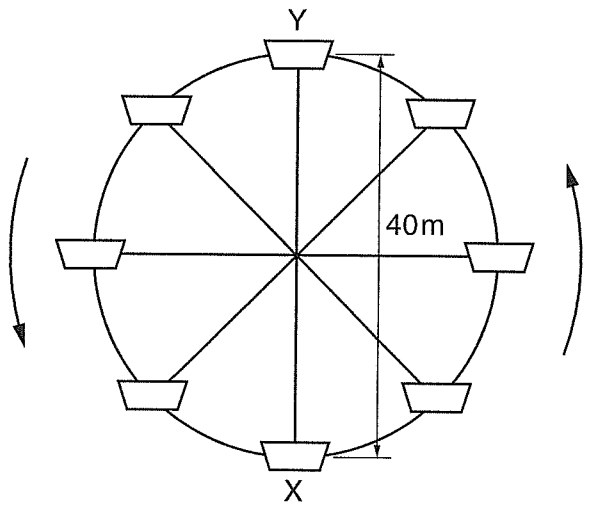

Fig. 1.1

(i) A carriage moves half a revolution from X to Y. Calculate

1. the speed of the carriage

speed = ... $m\,s^{-1}$

2. the magnitude of the average velocity of the carriage.

magnitude of the average velocity = ... $m\,s^{-1}$
[4]

(ii) The carriage in **(b)(i)** returns to point X. Calculate, for the **complete revolution**,

1. the speed of the carriage

speed = ... $m\,s^{-1}$

2. the average velocity of the carriage.

average velocity = ... $m\,s^{-1}$

Comment on your answer.

.....

..... [3]

(c) Describe how the instantaneous velocity of the carriage at Y differs from the average velocity of the carriage after travelling from X to Y.

.....

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.....

..... [3]
[Total: 14]

2 **(a)** A plane has an air speed of 240 km h^{-1} due north. A wind is blowing at 90 km h^{-1} from east to west. Use a vector triangle to calculate the resultant velocity of the plane.

velocity = ... m s^{-1},

direction with respect to north = ... °

[4]

(b) The plane flies under these conditions for 10 minutes. Calculate the component of the displacement

1. due north,

displacement =..... km

2. due west.

displacement = ... km

[2]

[Total: 6]

3 **(a)** Define *acceleration*.

.....

..... [1]

(b) Fig. 3.1 shows the variation of the velocity v, with the time t, of a train as it travels from one station to the next. The mass of the train is 105 tonnes.

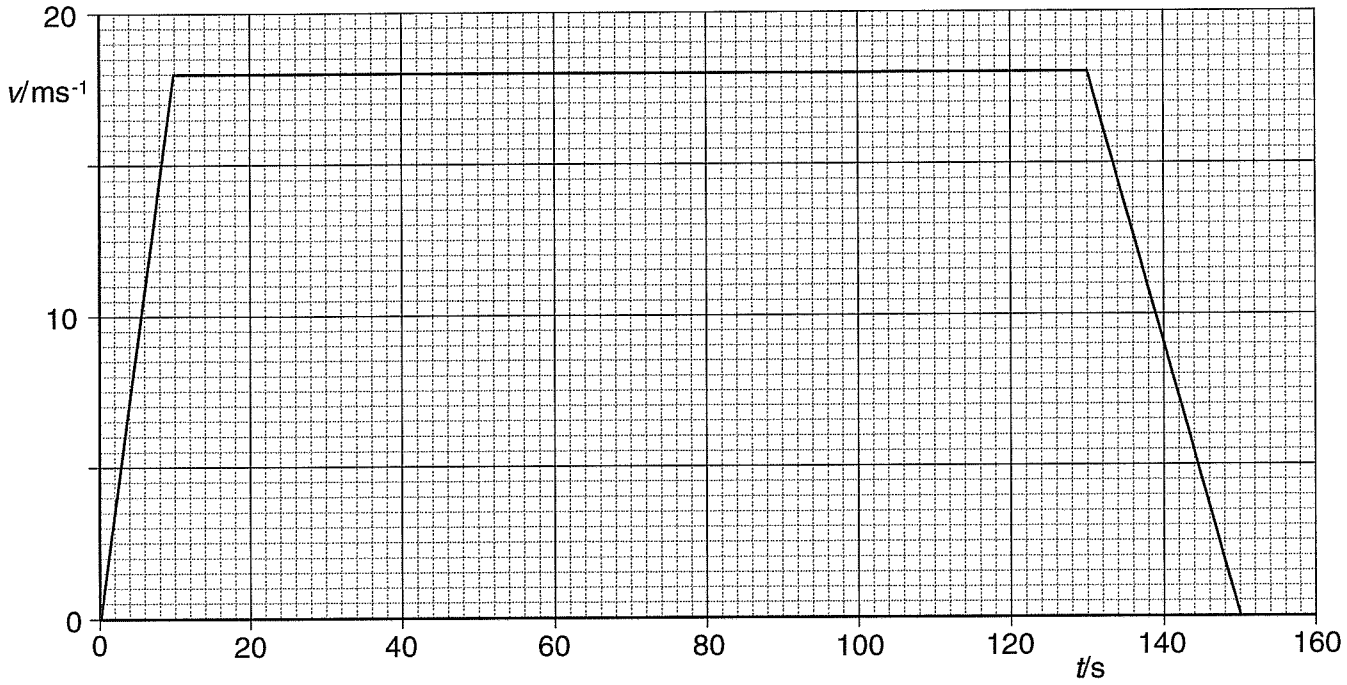

Fig. 3.1

(i) Use Fig. 3.1 to calculate the acceleration of the train in the first 10.0 s.

acceleration = ... $m\,s^{-2}$ [2]

(ii) Calculate the resultant force acting on the train during the first 10.0 s.

resultant force = ... N [2]

[Turn over

(iii) Use Fig. 3.1 to calculate the distance between the two stations.

distance = ... m [3]

(c) When travelling at a constant velocity of $18\,m\,s^{-1}$ the engine of the train provides 225 kW of motive power. Calculate the driving force acting on the train.

driving force = ... N [2]

(d) Explain why the train would reach a maximum constant velocity when the engine is supplying full power.

.....

.....

.....

..... [2]

[Total: 12]

4 **(a)** Define *density*.

.....

..... [1]

(b) Fig. 4.1 shows a swimming pool with a base of surface area 80 m^2. The pool contains water of density 1000 $kg\,m^{-3}$ to a uniform depth of 1.2 m.

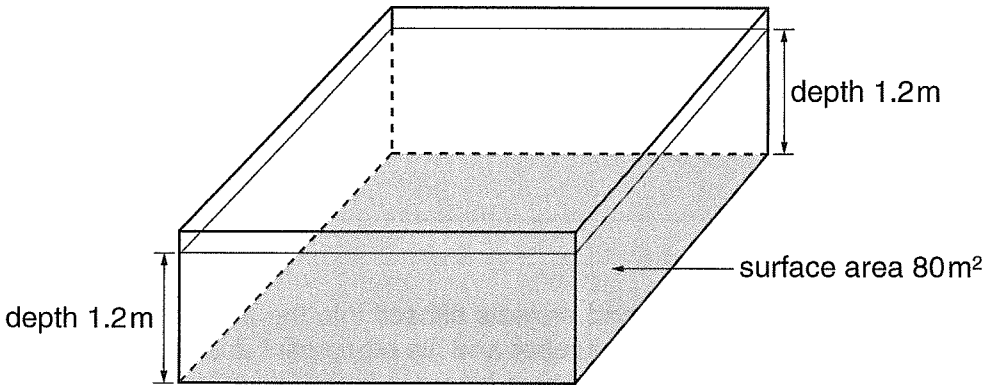

Fig. 4.1

(i) Show that the weight of water in the pool is 9.4×10^5 N.

[2]

(ii) Calculate the pressure exerted on the base of the pool by the water.

pressure = ... unit ..... [3]

(c) A second pool, of base area $40m^2$, has water of the same density and depth as that in the pool in part **(b)**. Determine the pressure of the water on the base of this pool.

pressure = ...

Comment on your answer.

.....

..... [2]

[Total: 8]

5 A ski jumper skis down a runway and projects himself into the air, landing on the ground a short time later. The mass of the ski jumper and his equipment is 80 kg. Fig. 5.1 shows the skier just before he leaves the runway where his velocity is 20 m s^{-1} in a horizontal direction.

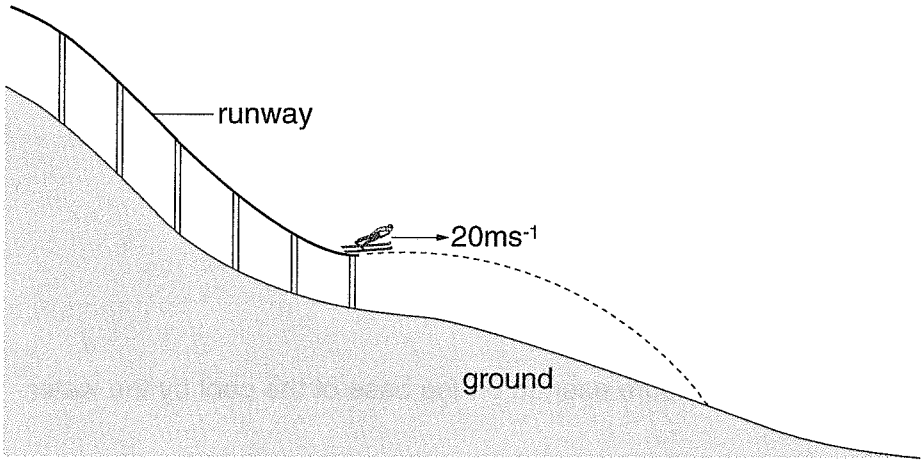

Fig. 5.1

(a) The skier lands 4.0 s after leaving the runway. Assume that only a gravitational force acts on the skier. Calculate

(i) the horizontal distance travelled by the skier in 4.0 s

horizontal distance = ... m [1]

(ii) the vertical fall of the skier in this 4.0 s

vertical fall = ... m [3]

(iii) the horizontal component of the skier's velocity immediately before he lands

horizontal component = ...$m\,s^{-1}$ [1]

(iv) the vertical component of the skier's velocity immediately before he lands.

vertical component = ... $m\,s^{-1}$ [2]

(b) (In this question, marks are available for the quality of written communication.)

Take **all** the forces that act on the skier into account.

(i) State the forces that act on the skier when he is in the air.

.....

.....

..... [2]

(ii) Discuss the energy changes that occur as the skier travels down the runway and explain how the skier attempts to increase the horizontal distance he travels before landing on the ground.

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[7]

[Total: 16]

6 **(a)** **(i)** Define *moment of a force* about a point.

.....

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(ii) Define *torque of a couple.*

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..... [3]

(b) Fig. 6.1 shows the steering wheel of a car being acted on by two equal forces.

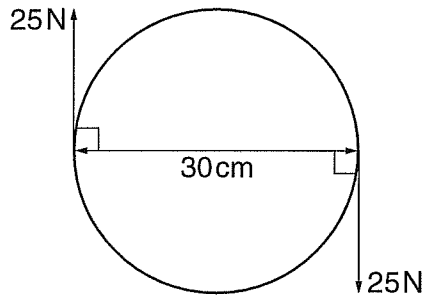

Fig. 6.1

(i) Calculate the torque acting on the wheel due to these forces.

torque ..... unit ..... [2]

(ii) Explain whether the steering wheel is in equilibrium when subjected to these two forces only.

.....

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..... [2]

[Total: 7]

7 **(a)** Define the *Young modulus* of a material.

.....

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..... [2]

(b) A metal wire of length 1.80 m is clamped vertically and a load is applied so that it extends 0.55 mm. The cross-sectional area of the wire is 1.2×10^{-7} m^2 and the Young modulus of the metal is 2.0×10^{11} Pa.

(i) Calculate the strain.

strain = ...

(ii) Calculate the force applied.

force = ... N
[4]

(c) **(i)** Determine the extension produced on a second metal wire that has the same dimensions as the wire in part **(b),** has the same load applied but is made from a material that has half the Young modulus value.

extension = ... mm

(ii) State **one** assumption made.

.....

..... [3]
[Total: 9]

8 **(a)** A car of total mass 800 kg is travelling along a level road at 25 m s^{-1}. The thinking time of the driver is 0.65 s and the braking distance for the car travelling at this speed is 40 m.

(i) Calculate the overall stopping distance.

stopping distance = ... m

(ii) Calculate the kinetic energy of the car before the brakes are applied.

kinetic energy = ... J

(iii) Calculate the average braking force of the car.

braking force = ... N

[7]

(b) Explain why the following factors affect the stopping distance of a car.

(In this question, marks are available for the quality of written communication.)

(i) a wet road

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(ii) tyre tread

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(iii) downward slope in the road.

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..... [7]

[Total: 14]

Quality of Written Communication [4]