RECOGNISING ACHIEVEMENT

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**
**Advanced Subsidiary GCE**

# PHYSICS A

# 2821

Forces and Motion

Friday **6 JUNE 2003** Afternoon 1 hour

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

| Candidate Name | Centre Number | Candidate Number |
|---|---|---|
| | | |

**TIME** 1 hour

## 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 provided 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 | 6 | |
| 2 | 9 | |
| 3 | 11 | |
| 4 | 8 | |
| 5 | 9 | |
| 6 | 17 | |
| **TOTAL** | **60** | |

**This question paper consists of 15 printed pages and 1 blank page.**

SP (AT/TC) S29220/5

**[Turn over**

2044

**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, $n = \dfrac{1}{\sin C}$

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

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

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

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

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

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

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

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

current, $I = nAve$

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

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

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For Examiner's Use

Answer **all** the questions.

1 **(a)** Fig. 1.1 shows a table of vector and scalar quantities.

| | |
|---|---|
| speed, acceleration | |
| energy, power | |
| force, pressure | |
| velocity, displacement | |

**Fig. 1.1**

In the blank spaces provided in Fig. 1.1, label the pair of quantities that are both vectors with a V and the pair that are both scalars with an S. [2]

**(b)** Fig. 1.2 shows the path taken by an athlete when she runs a 200 m race in 24 s from the start position at S to the finish at F.

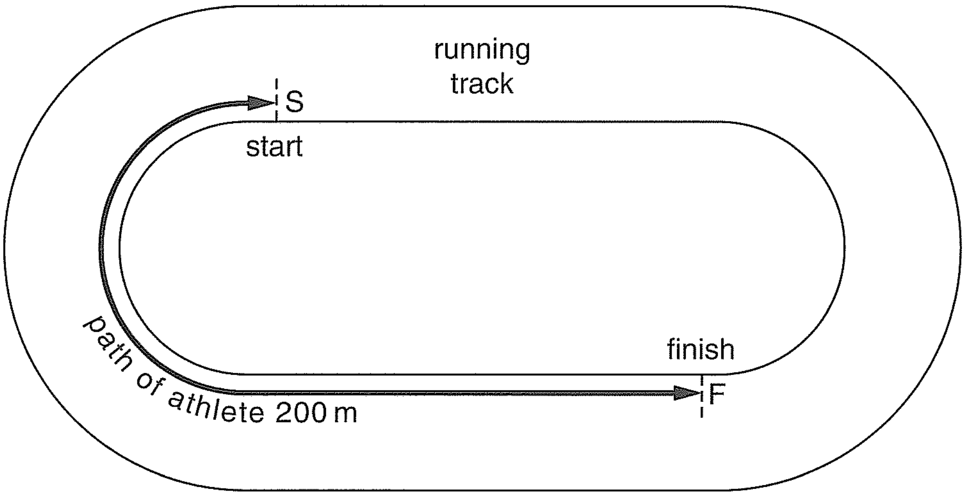


**Fig. 1.2**

**(i)** Calculate the average speed of the athlete.

average speed = ........................................ $m\,s^{-1}$ [2]

**(ii)** Explain how the magnitude of the average velocity of the athlete would differ from her average speed. A quantitative answer is not required.

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[Total: 6]

For Examiner's Use

**2** Fig. 2.1 shows a boy on a sledge travelling down a slope. The boy and sledge have a total mass of 60 kg and are travelling at a constant speed. The angle of the slope to the horizontal is 35°. All the forces acting on the boy and sledge are shown on Fig. 2.1 and in a force diagram in Fig. 2.2.

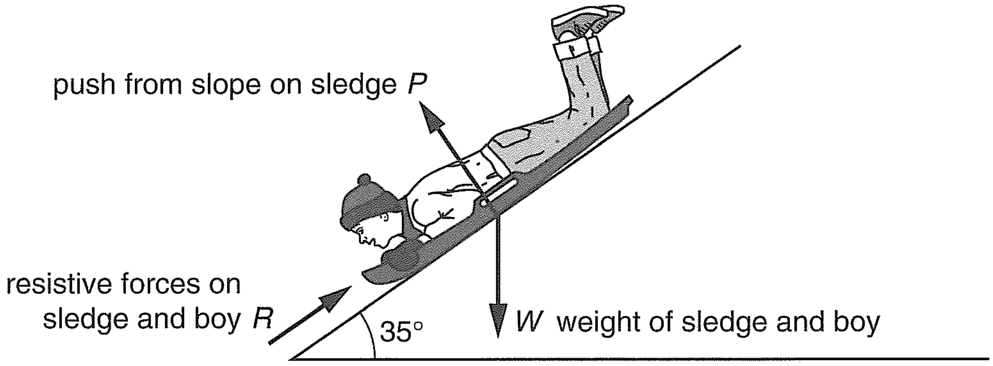


**Fig. 2.1**

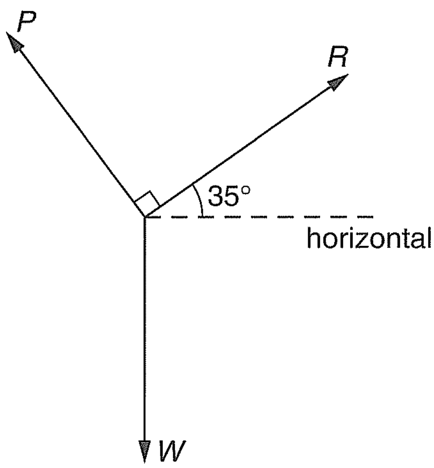


**Fig. 2.2**

**(a)** Calculate the magnitude of $W$, the total weight of the boy and sledge.

weight $W$ = .................................................... N [1]

For Examiner's Use

**(b)** Determine the magnitude of the resistive force $R$.
You may find it helpful to draw a vector triangle.

resistive force $R$ = ............................................. N [4]

**(c)** Determine the component of the weight $W$ that acts perpendicular to the slope.

component of $W$ = ............................................. N [2]

**(d)** State and explain why the boy is travelling at constant speed even though he is moving down a slope.

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[Total: 9]

For Examiner's Use

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

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**(b)** An aircraft of total mass $1.5 \times 10^5$ kg accelerates, at maximum thrust from the engines, from rest along a runway for 25 s before reaching the required speed for take-off of 65 m s$^{-1}$.
Assume that the acceleration of the aircraft is constant.

Calculate

**(i)** the acceleration of the aircraft

acceleration = ............................................m s$^{-2}$ [3]

**(ii)** the force acting on the aircraft to produce this acceleration

force = ....................................................... N [2]

**(iii)** the distance travelled by the aircraft in this time.

distance = .....................................................m [2]

For Examiner's Use

**(c)** The length of runways at some airports is less than the required distance for take-off by this aircraft calculated in **(b)(iii)**.
State and explain **one** method that could be adopted for this aircraft so that it could reach the required take-off speed on shorter runways.

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..........................................................................................................................................[2]

[Total: 11]

For Examiner's Use

**4** **(a)** Define

**(i)** power ..........................................................................................................

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**(ii)** a joule ..........................................................................................................

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**(b)** Fig. 4.1 shows part of a fairground ride with a carriage on rails.

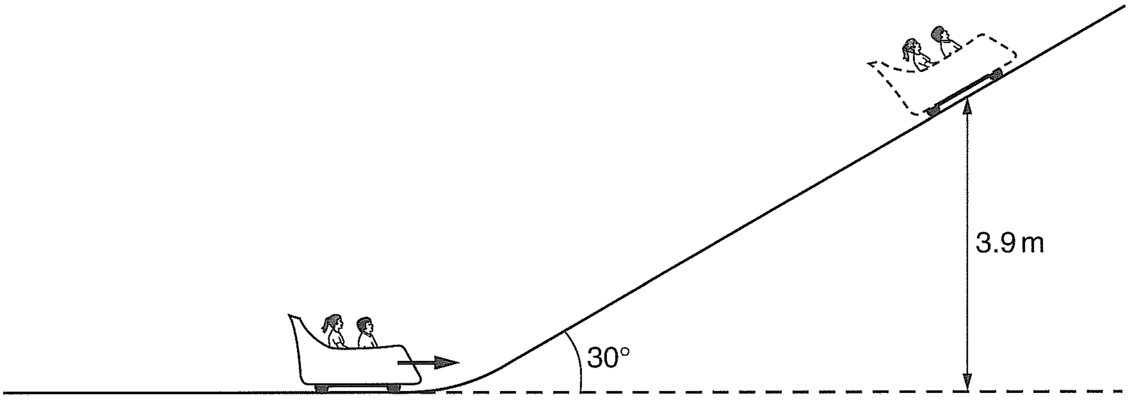


**Fig. 4.1**

The carriage of mass 500 kg is travelling towards a slope inclined at 30° to the horizontal. The carriage has a kinetic energy of 25 kJ at the bottom of the slope. The carriage comes to rest after travelling up the slope to a vertical height of 3.9 m.

**(i)** Show that the potential energy gained by the carriage is 19 kJ.

[2]

**(ii)** Calculate the work done against the resistive forces as the carriage moves up the slope.

work done = ................................................ kJ [1]

(iii) Calculate the resistive force acting against the carriage as it moves up the slope.

resistive force = .................................................. N [3]

[Total: 8]

5 (a) State Hooke's law.

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(b) Explain what is meant by the spring constant.

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For Examiner's Use

**(c)** Fig. 5.1 shows the variation of the force $F$ with the extension $x$ for a particular spring.

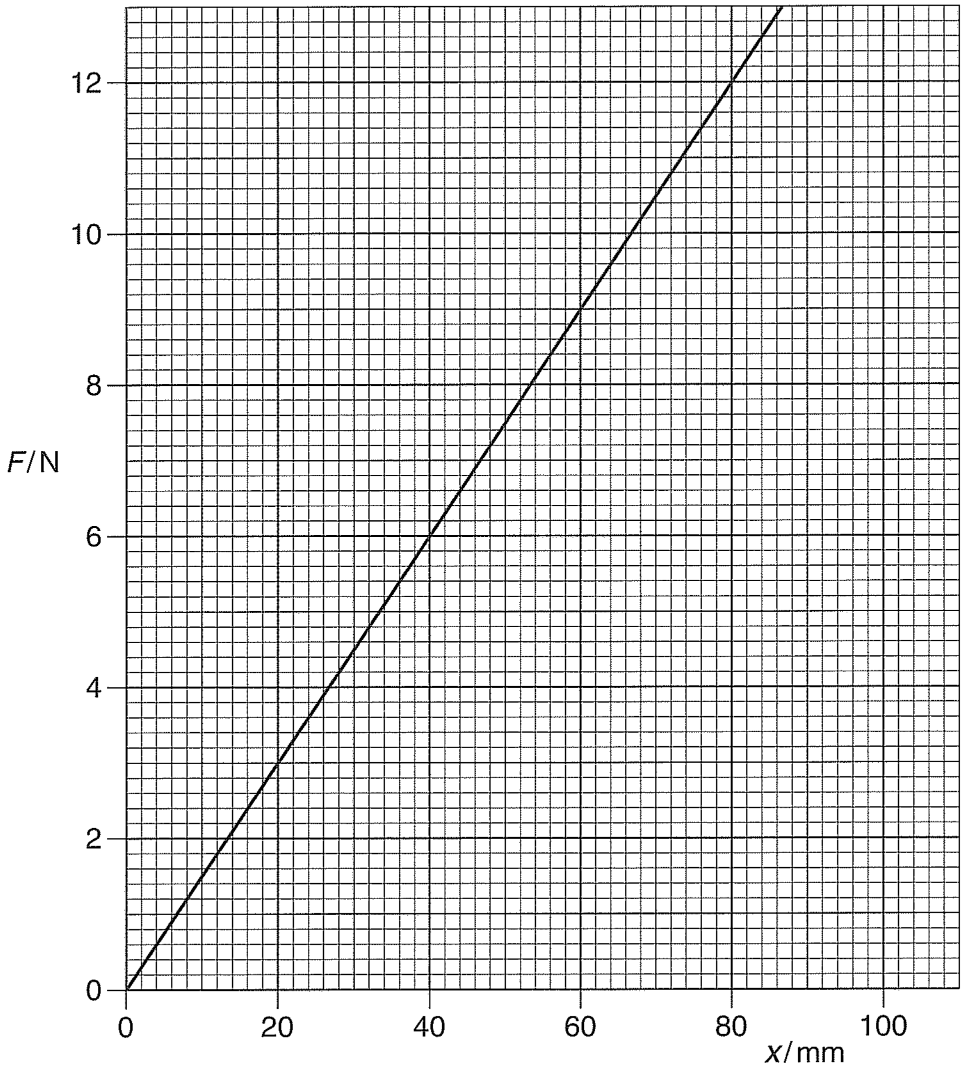


**Fig. 5.1**

**(i)** Calculate the spring constant for the spring.

spring constant = ................................ unit ............ [3]

**(ii)** Calculate the energy stored in the spring when a force of 12 N is applied.

energy stored = ................................................ J [3]

[Total: 9]

**6** In this question, two marks are available for the quality of written communication.

**(a)** Explain the term *braking distance* in relation to the motion of a road vehicle.

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Fig. 6.1 shows how the braking distance for a car of mass 800 kg varies with its initial speed when a constant braking force is applied.

| speed / m $s^{-1}$ | 0 | 10 | 20 | 30 | 40 |
|---|---|---|---|---|---|
| braking distance / m | 0 | 6 | 24 | 54 | |

**Fig. 6.1**

**(b)** Calculate the kinetic energy of the car when it is travelling at 20 m $s^{-1}$.

kinetic energy = ................................................ J [3]

For Examiner's Use

**(c)** Explain why the braking distance is **not** proportional to the speed of the car when the braking force is constant.

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**(d)** Calculate the braking distance for this car when it is travelling at $40\,m\,s^{-1}$ assuming the same braking force is applied.

braking distance = ............................................. m [2]

For Examiner's Use

**(e)** Discuss in terms of the force acting on the driver of a car, how a seat belt can help to protect the driver from injury in a head on collision. Suggest briefly how air bags give additional protection to the driver.

seat belt ..........................................................................................................

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air bags ..........................................................................................................

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Quality of Written Communication [2]

[Total: 17]