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# OXFORD AQA INTERNATIONAL AS PHYSICS

## Unit 2 Electricity, waves and particles

Thursday 25 January 2018

06:00 GMT

Time allowed: 2 hours

### Materials

For this paper you must have:

- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

### Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

### Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use

| Question     | Mark |
|--------------|------|
| 1            |      |
| 2            |      |
| 3            |      |
| 4            |      |
| 5            |      |
| 6            |      |
| 7            |      |
| 8            |      |
| 9            |      |
| 10–23        |      |
| <b>TOTAL</b> |      |



**Section A**Answer **all** questions in this section.

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 Outline what is meant by a superconductor.**[2 marks]**

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 State **one** application of superconductors.**[1 mark]**

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 X-rays and ultrasound are used in medical imaging.

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 State **one** advantage of using X-rays instead of ultrasound in medical imaging.**[1 mark]**

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 Describe why ultrasound, rather than X-rays, is used to produce an image of a fetus.**[2 marks]**

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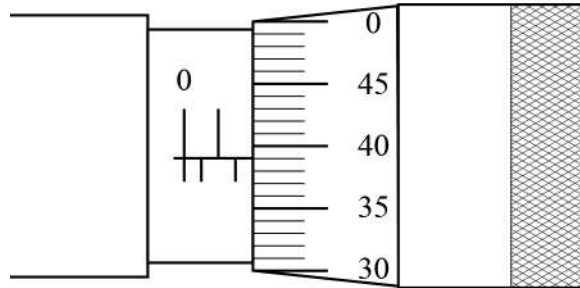


0 3

A student uses a micrometer, that has no zero error, to measure the diameter of a copper wire.

**Figure 1** shows the micrometer scales as the diameter is measured.

**Figure 1**



0 3 . 1

Show that the cross-sectional area of the wire is about  $2.8 \times 10^{-6} \text{ m}^2$

[2 marks]

0 3 . 2

The resistivity of copper is  $1.7 \times 10^{-8} \Omega \text{ m}$   
The wire has a length of 85 cm

Calculate the resistance of the wire.

Give your answer to an appropriate number of significant figures.

[3 marks]

resistance = \_\_\_\_\_  $\Omega$

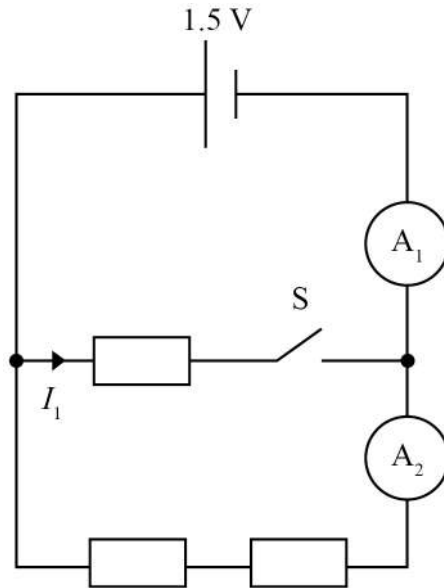
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0 4

**Figure 2** shows three identical resistors, each with a resistance  $R$ , in a circuit connected to a cell with emf  $1.5\text{ V}$ . The cell has negligible internal resistance.

**Figure 2**

0 4 . 1

When switch  $S$  is closed the reading of ammeter  $A_1$  is  $1.2\text{ A}$  and the reading of ammeter  $A_2$  is  $0.40\text{ A}$ .

State the value of the current  $I_1$  when switch  $S$  is closed.

**[1 mark]**

$$I_1 = \underline{\hspace{2cm}} \text{ A}$$

0 4 . 2

Calculate  $R$ .

**[1 mark]**

$$R = \underline{\hspace{2cm}} \Omega$$



**0 4 . 3** Switch S is returned to the open position.

State and explain the effect this has on the readings of  $A_1$  and  $A_2$ .

**[3 marks]**

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**5**

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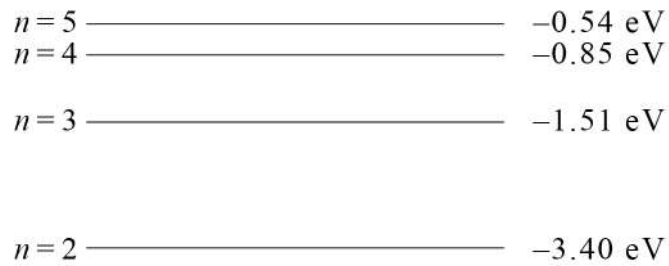
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0 5

Figure 3 shows some of the energy levels for a hydrogen atom.

Figure 3



ground state  $n = 1$  —————  $-13.60 \text{ eV}$

0 5 . 1

A hydrogen atom is in the ground state. It absorbs all the energy of a photon and becomes excited to the  $n = 3$  energy level.

Calculate the frequency of the photon absorbed by the hydrogen atom.

[3 marks]

frequency = \_\_\_\_\_ Hz

0 5 . 2

State, in eV, the ionisation energy of a hydrogen atom.

[1 mark]

ionisation energy = \_\_\_\_\_ eV



**0 5 . 3** A photon with an energy of 18.4 eV interacts with a hydrogen atom in its ground state.

Describe how the principle of energy conservation could apply in this situation.

**[3 marks]**

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**7**

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06.1

Describe the nature of an electromagnetic wave.

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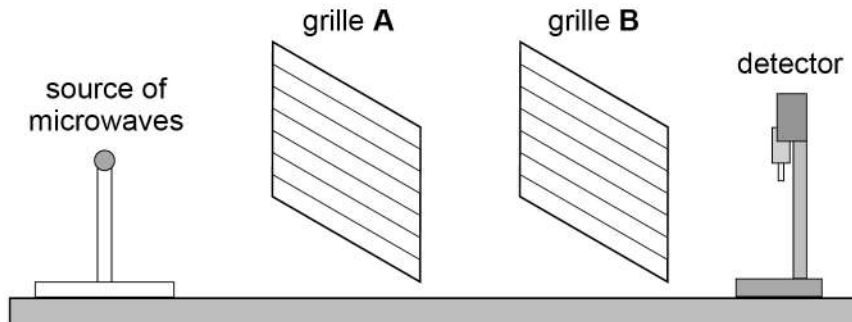




0 6 . 2

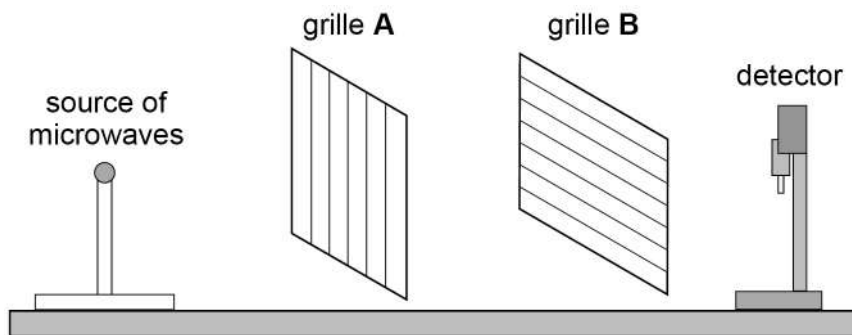
A source of microwaves and a detector are set up with two metal grilles **A** and **B** between them, as shown in **Figure 4**. The reading on a voltmeter connected to the detector is 5 mV. Each grille consists of a series of parallel, thin, metal rods.

**Figure 4**



Grille **A** is rotated through  $90^\circ$  about a horizontal axis as shown in **Figure 5**.

**Figure 5**



Explain the changes in the voltmeter reading as grille **A** is rotated.

**[2 marks]**

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0 7 . 1 Define the electromotive force (emf) of a battery.

[2 marks]

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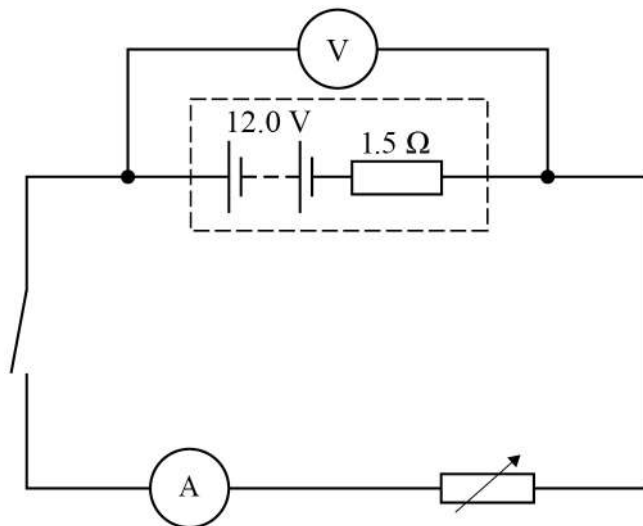
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0 7 . 2 A battery with an emf of 12.0 V and an internal resistance of 1.5  $\Omega$  is connected in the circuit shown in **Figure 8**.

**Figure 8**



The voltmeter reading is 9.0 V when the current in the circuit is 2.0 A

Calculate the resistance of the variable resistor when the voltmeter reads 9.0 V

[2 marks]

resistance = \_\_\_\_\_  $\Omega$



**0 7 . 3** Determine the maximum current that can be provided by the battery.

**[2 marks]**

maximum current = \_\_\_\_\_ A

**0 7 . 4** With the switch closed the variable resistor is adjusted to obtain a range of ammeter and voltmeter readings. Finally the switch is opened and a final ammeter and voltmeter reading are obtained.

Sketch on **Figure 9** a graph to show the variation of voltmeter reading  $V$  with current  $I$ .

Label your axes with suitable numerical values.

**[2 marks]**

**Figure 9**



**Question 7 continues on the next page**

**Turn over ►**



**0 7 . 5**

The battery, when fully charged, can deliver a total charge of  $1.15 \times 10^4 \text{ C}$

For a particular application, the fully-charged battery is required to supply a constant current to an external circuit of resistance  $0.1 \Omega$  for 30 minutes.

Discuss the suitability of the battery for this application.

You should use calculations to support your answer.

**[3 marks]**

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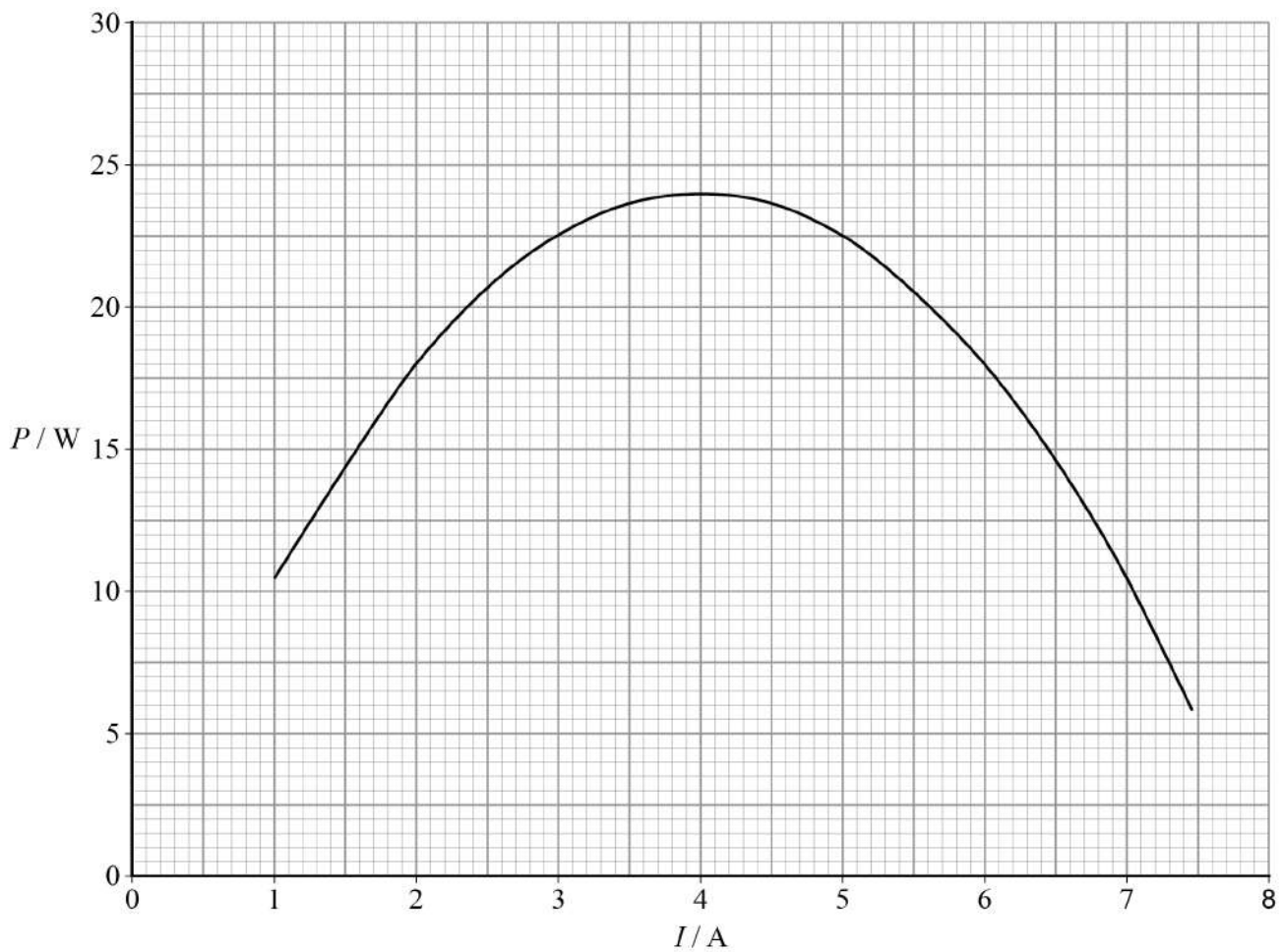
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0 7 . 6

**Figure 10** shows the variation with current of the power dissipated in the variable resistor.

**Figure 10**



Calculate using data from **Figure 10** the value of the variable resistance when  $P$  is a maximum.

**[3 marks]**

variable resistance = \_\_\_\_\_  $\Omega$

**Question 7 continues on the next page**

**Turn over ►**



0 7 . 7

**Figure 10** suggests that as the current increases past 7.5 A, the power dissipated in the variable resistor eventually reaches zero.

Explain why the circuit behaves in this way.

**[2 marks]**

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16

**END OF SECTION A**





## Section B

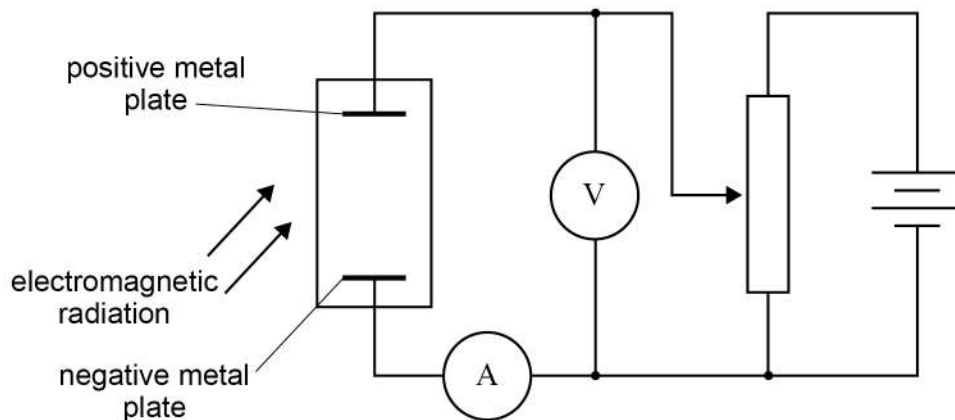
Answer **all** questions in this section.

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0 8

The variation of the maximum kinetic energy of photoelectrons with the wavelength of incident electromagnetic radiation may be investigated using the apparatus in **Figure 11**.

**Figure 11**



When the positive metal plate is illuminated with monochromatic electromagnetic radiation of a sufficiently high frequency, electrons are emitted and move towards the negative plate, causing a current in the circuit. The potential difference between the positive plate and the negative plate is adjusted until the current is zero. When this happens, the potential difference measured by the voltmeter is called the stopping potential  $V_s$ .

The maximum kinetic energy of the photoelectrons  $E_{k(\max)}$  is  $eV_s$ .

**Question 8 continues on the next page**

Turn over ►



**0 8 . 1** In one experiment, the results in **Table 1** were obtained:

**Table 1**

| Frequency of incident radiation / $10^{14}$ Hz | $V_s / V$                           | $E_{k(\max)} / 10^{-20}$ J |
|--|-------------------------------------|----------------------------|
| 6.0  | $0.15 \pm \underline{\hspace{2cm}}$ | $2.4 \pm 0.8$              |
| 6.8  | $0.55 \pm \underline{\hspace{2cm}}$ | $8.6 \pm 0.8$              |
| 7.5  | $0.80 \pm \underline{\hspace{2cm}}$ | $12.8 \pm 0.8$             |
| 8.6  | $1.25 \pm \underline{\hspace{2cm}}$ | $20.0 \pm 0.8$             |

Complete **Table 1** by calculating the values of the absolute uncertainties of  $V_s$ .

**[1 mark]**

**0 8 . 2** The values of frequency and  $E_{k(\max)}$  have been plotted on **Figure 12**.

Complete the graph by adding error bars for each point and by drawing a best fit straight line.

Assume that there is negligible uncertainty in the values of frequency.

**[2 marks]**

**0 8 . 3** The equation for the graph is:

$$E_{k(\max)} = hf - \phi$$

where  $h$  is the Planck constant and  $\phi$  is the work function of the metal from which the positive plate is made.

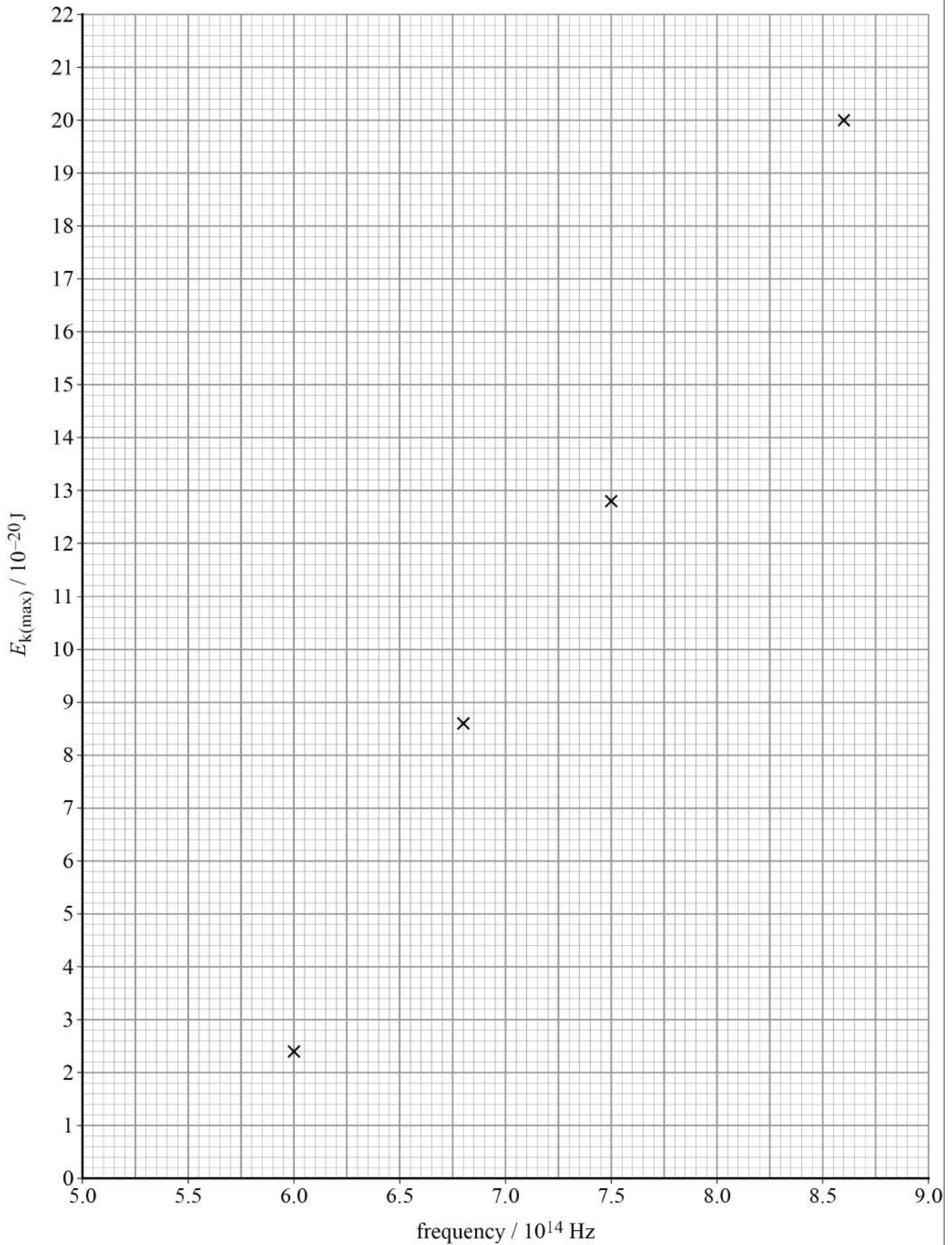
Determine using your graph a value for  $h$ .

**[2 marks]**

$$h = \underline{\hspace{2cm}} \text{ J s}$$



Figure 12



Question 8 continues on the next page

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**0 8 . 4** Photoelectrons are not emitted below a threshold frequency  $f_0$ .

Determine using your graph the value of  $f_0$ .

[1 mark]

$$f_0 = \text{_____ Hz}$$

**0 8 . 5** Determine using your graph the uncertainty in your value of  $f_0$ .

[2 marks]

$$\text{uncertainty in } f_0 = \pm \text{_____ Hz}$$

**0 8 . 6** Suggest **one** way in which the results in question **08.1** could be improved.

[1 mark]

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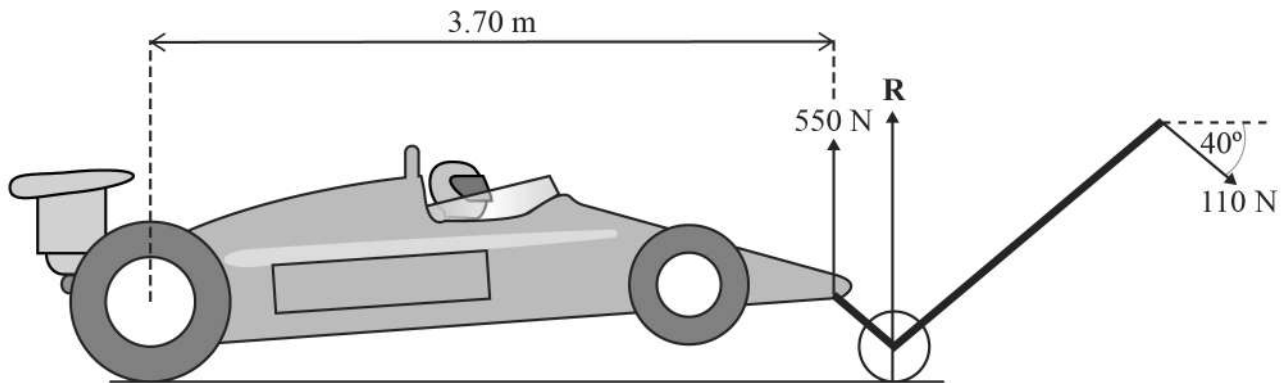
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0 9

A racing car of mass 760 kg stops for a tyre change.  
A mechanic uses a lever to hold the car in equilibrium as shown in **Figure 13**.  
The lever exerts a vertical force of 550 N on the car.

Figure 13



0 9 . 1

Draw and label **two** other vertical forces acting on the car in **Figure 13**.

[2 marks]

0 9 . 2

Calculate the horizontal distance between the centre of the rear wheel and the centre of mass of the car.

[2 marks]

distance = \_\_\_\_\_ m



0 9 . 3

The mechanic exerts a force on the lever of 110 N at  $40^\circ$  to the horizontal as shown in **Figure 13**. The normal reaction force of the ground on the lever is **R**.

Calculate the magnitude of **R**.

[3 marks]

magnitude of **R** = \_\_\_\_\_ N

7

**END OF SECTION B**

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**Section C**

Each of the questions in this section is followed by four responses **A, B, C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.


For each answer completely fill in the circle alongside the appropriate answer.


CORRECT METHOD



WRONG METHODS



If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

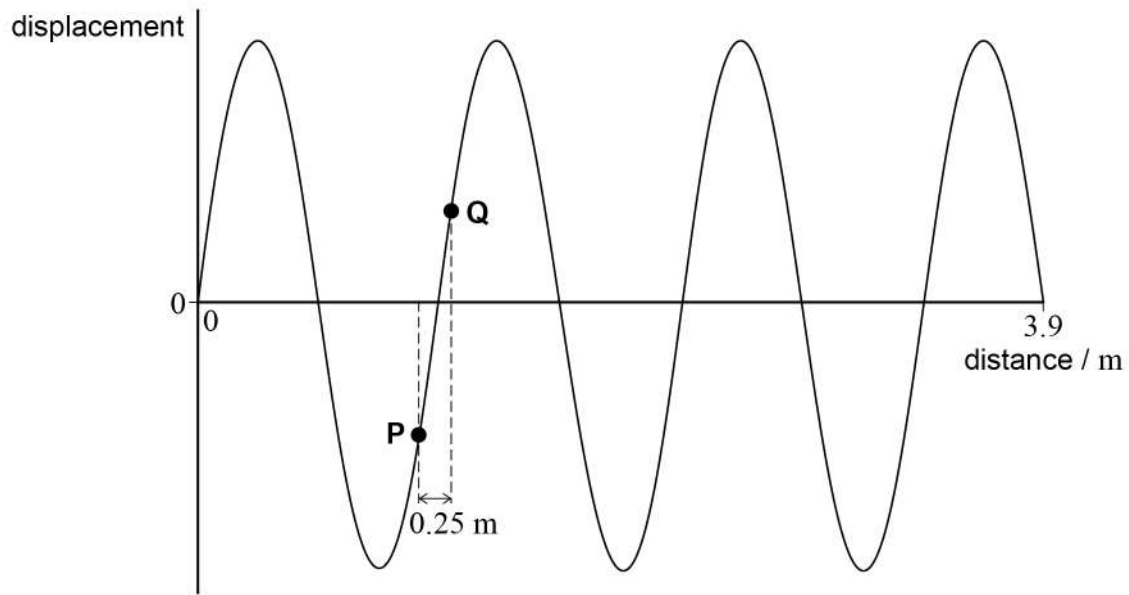
You may do your working in the blank space around each question but this will not be marked.  
Do **not** use additional sheets for this working.





**1 0**

The graph shows the variation with distance of the displacement of a progressive wave.



What is the phase difference between points **P** and **Q**?

**[1 mark]**

- A** 0.22 rad  
**B** 0.40 rad  
**C** 1.2 rad  
**D** 1.4 rad

**1 1**

Which is equivalent to the SI unit of resistivity?

**[1 mark]**

- A**  $\text{A V}^{-1} \text{m}^{-1}$   
**B**  $\text{C}^{-1} \text{V s m}$   
**C**  $\text{V A m}$   
**D**  $\text{C V m s}^{-1}$

Turn over ►



**1 2**

When a mass  $m$ , suspended from a spring with spring constant  $k$ , is set into simple harmonic motion it oscillates with time period  $T$ .

What is the time period of a mass  $2m$  suspended from a spring with a spring constant  $\frac{k}{2}$ ?  
[1 mark]

**A**  $\frac{T}{2}$

**B**  $\frac{T}{\sqrt{2}}$

**C**  $\sqrt{2} T$

**D**  $2T$

**1 3**

The cladding of a step-index optical fibre

[1 mark]

**A** reduces material dispersion.

**B** reduces signal loss.

**C** must have a higher refractive index than the core.

**D** must be opaque.

**1 4**

Monochromatic light of wavelength 610 nm illuminates a double slit. An interference pattern is observed on a screen 4.5 m from the slits. Consecutive bright fringes are 1.1 cm apart.

What is the slit separation?

[1 mark]

**A** 0.0025 mm

**B** 0.025 mm

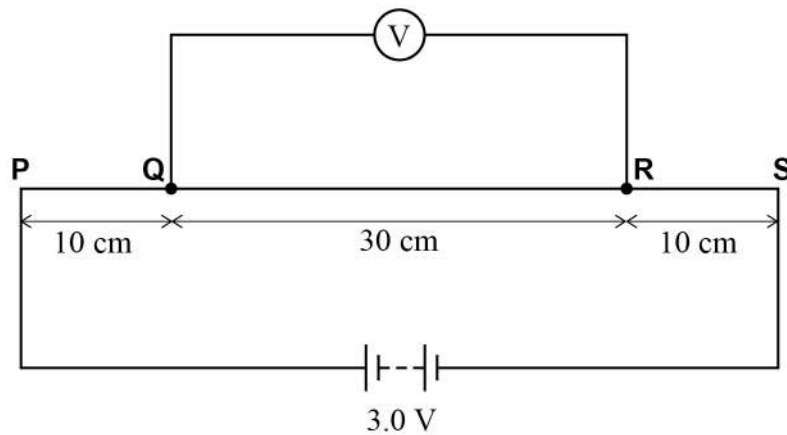
**C** 0.25 mm

**D** 2.5 mm



1 5

A length **PQRS** of resistance wire of uniform cross-section is connected to a battery of emf 3.0 V and negligible internal resistance.



What is the reading on the voltmeter?

[1 mark]

**A** 0.6 V

**B** 1.2 V

**C** 1.8 V

**D** 2.4 V

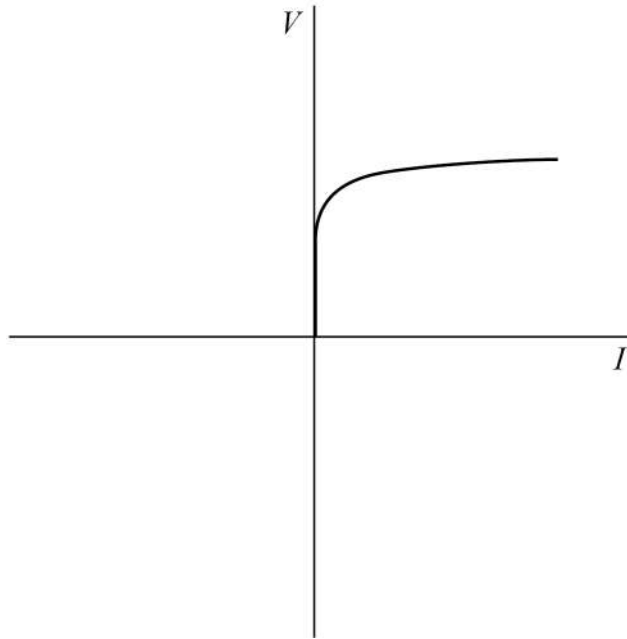
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**1 6**

Which component has the voltage–current ( $V$ – $I$ ) characteristics shown by the graph below?

**[1 mark]**

**A** filament lamp

**B** metal conductor at constant temperature

**C** semiconductor diode

**D** thermistor

**1 7**

A diffraction grating has a spacing of  $3.0 \mu\text{m}$

Light of wavelength  $610 \text{ nm}$  is incident normally on the diffraction grating.

What is the largest order obtained?

**[1 mark]**

**A** 2nd

**B** 4th

**C** 5th

**D** 8th



**1 8**

What is the de Broglie wavelength of an electron travelling at 30% of the speed of light?

Ignore any relativistic effects.

**[1 mark]**

**A**  $2.4 \times 10^{-14}$  m

**B**  $8.1 \times 10^{-14}$  m

**C**  $2.4 \times 10^{-12}$  m

**D**  $8.1 \times 10^{-12}$  m

**1 9**

The refractive index for light passing from air into medium **A** is 1.3

The refractive index for light passing from air into medium **B** is 1.6

Which statement is **not** correct?

**[1 mark]**

**A** The critical angle for light travelling from **A** into **B** is about  $54^\circ$

**B** Light travelling from **B** into **A** will refract away from the normal.

**C** The speed of light in **A** is about  $0.77c$

**D** Light travels slower in **B** than in **A**.

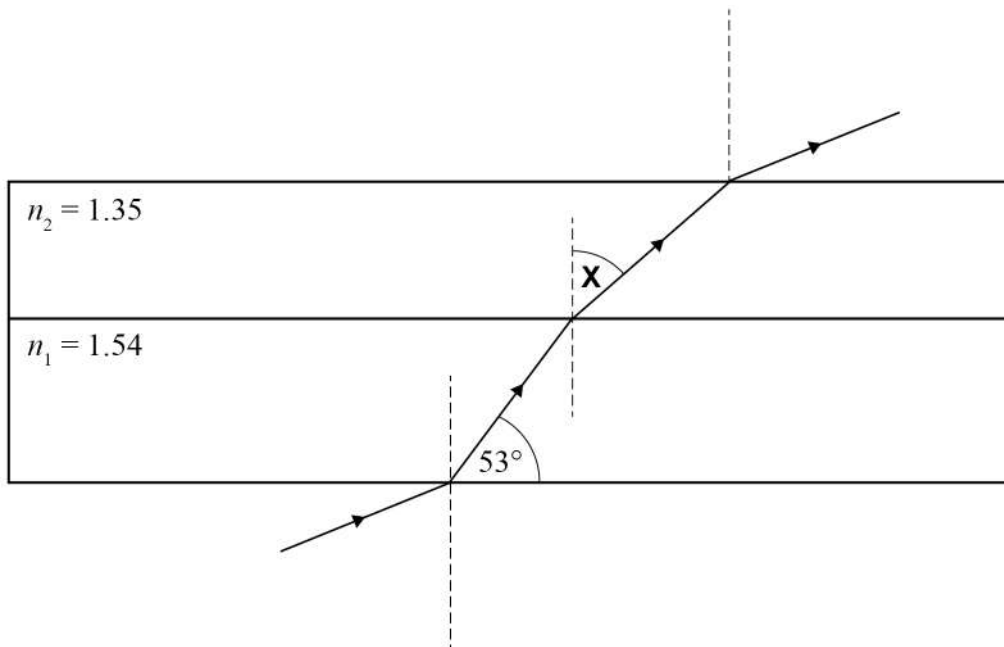
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**2 0**

The diagram shows the path of a ray of light through two transparent parallel layers.

The refractive indices shown on the diagram are for light travelling from air into each medium.

**[1 mark]**

What is angle  $X$ ?

**A**  $32^\circ$

**B**  $37^\circ$

**C**  $43^\circ$

**D**  $67^\circ$



**2 1**

A student wishes to measure the slit separation of a double slit using the interference pattern produced by the slit.

Which row shows the source she should choose and the reason for her choice?

**[1 mark]**

|          | Source                  | Reason                                   |                       |
|----------|-------------------------|--|-----------------------|
| <b>A</b> | Monochromatic red light | The fringes will be brighter             | <input type="radio"/> |
| <b>B</b> | Monochromatic red light | The interference patterns do not overlap | <input type="radio"/> |
| <b>C</b> | White light             | The fringes will be brighter             | <input type="radio"/> |
| <b>D</b> | White light             | The interference patterns do not overlap | <input type="radio"/> |

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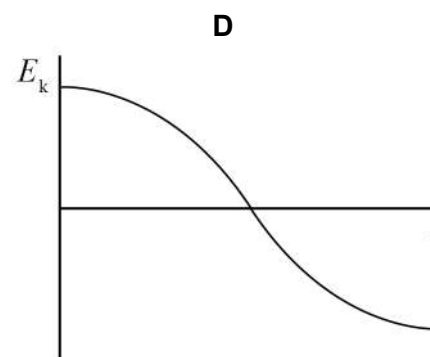
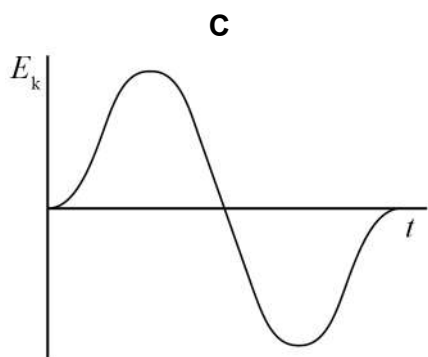
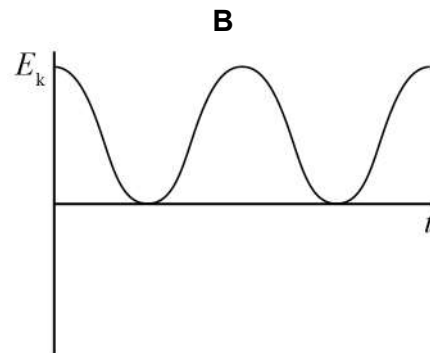
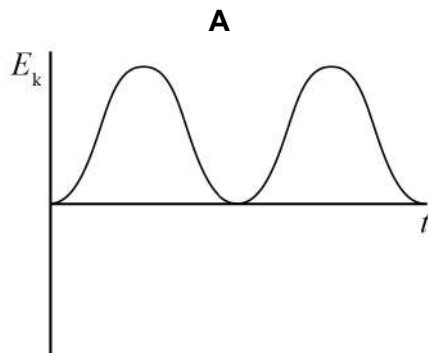
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2 2

A simple pendulum is released from its extreme position and completes one oscillation.

Which graph shows the variation of kinetic energy  $E_k$  with time  $t$  for the oscillation?

[1 mark]



**A**

**B**

**C**

**D**

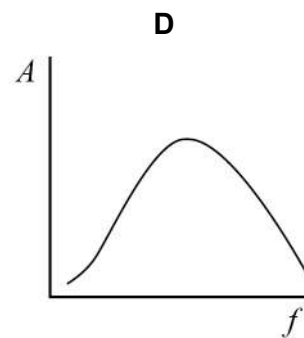
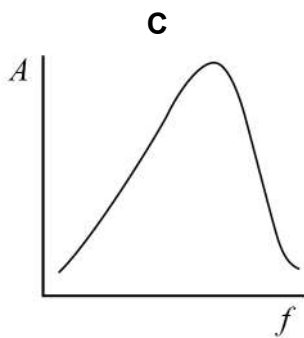
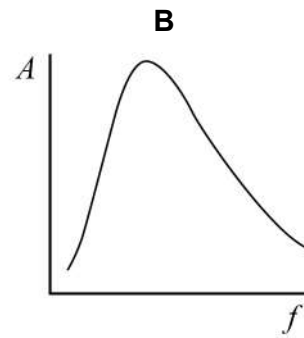
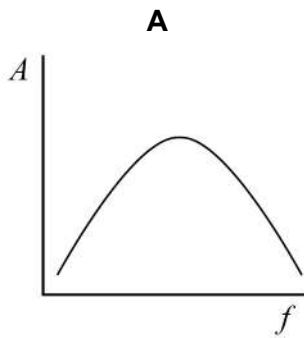




2 3

Which graph shows the variation of amplitude  $A$  with driving frequency  $f$  for a damped system undergoing forced oscillations?

[1 mark]

A B C D 

END OF QUESTIONS

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