

3220/201

SCOTTISH
CERTIFICATE OF
EDUCATION
1999

FRIDAY, 14 MAY
9.00 AM – 10.30 AM

PHYSICS
HIGHER GRADE
Paper I

Read Carefully

- 1 All questions should be attempted.
- 2 The following data should be used when required unless otherwise stated.

Speed of light in vacuum c	$3.00 \times 10^8 \text{ m s}^{-1}$	Planck's constant h	$6.63 \times 10^{-34} \text{ J s}$
Charge on electron e	$-1.60 \times 10^{-19} \text{ C}$	Mass of electron m_e	$9.11 \times 10^{-31} \text{ kg}$
Acceleration due to gravity g	9.8 m s^{-2}	Mass of proton m_p	$1.67 \times 10^{-27} \text{ kg}$

Section A (questions 1 to 30)

- 3 Check that the answer sheet is for Physics Higher I (Section A).
- 4 Answer the questions numbered 1 to 30 on the answer sheet provided.
- 5 Fill in the details required on the answer sheet.
- 6 Rough working, if required, should be done only on this question paper, or on the first two pages of the answer book provided—**not** on the answer sheet.
- 7 For each of the questions 1 to 30 there is only **one** correct answer and each is worth 1 mark.
- 8 Instructions as to how to record your answers to questions 1–30 are given on page two.

Section B (questions 31 to 37)

- 9 Answer questions numbered 31 to 37 in the answer book provided.
- 10 Fill in the details on the front of the answer book.
- 11 Enter the question number clearly in the margin of the answer book beside each of your answers to questions 31 to 37.
- 12 Care should be taken **not** to give an unreasonable number of significant figures in the final answers to calculations.



SECTION A

For questions 1 to 30 in this section of the paper, an answer is recorded on the answer sheet by indicating the choice A, B, C, D or E by a stroke made in ink in the appropriate box of the answer sheet—see the example below.

EXAMPLE

The energy unit measured by the electricity meter in your home is the

- A ampere
- B kilowatt-hour
- C watt
- D coulomb
- E volt.

The correct answer to the question is B—kilowatt-hour. Record your answer by drawing a heavy vertical line joining the two dots in the appropriate box on your answer sheet in the column of boxes headed B. The entry on your answer sheet would now look like this:

A	B	C	D	E
<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> <div style="position: absolute; top: 15px; bottom: 15px; left: 10px; right: 10px; background-color: black;"></div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>

If after you have recorded your answer you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:

A	B	C	D	E
<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> <div style="position: absolute; top: 15px; bottom: 15px; left: 10px; right: 10px; background-color: black;"></div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> <div style="position: absolute; top: 15px; bottom: 15px; left: 10px; right: 10px; background-color: black; clip-path: polygon(50% 0%, 50% 100%);"></div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>

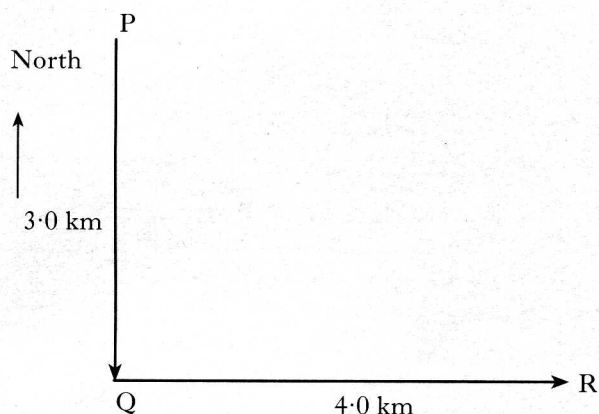
If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the RIGHT of the box of your choice, thus:

A	B	C	D	E	OR	A	B	C	D	E
<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> <div style="position: absolute; top: 15px; bottom: 15px; left: 10px; right: 10px; background-color: black;"></div> </div> ✓	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	OR	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> <div style="position: absolute; top: 15px; bottom: 15px; left: 10px; right: 10px; background-color: black;"></div> </div> ✓	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> <div style="position: absolute; top: 15px; bottom: 15px; left: 10px; right: 10px; background-color: black; clip-path: polygon(50% 0%, 50% 100%);"></div> </div>	<div style="border: 1px solid black; width: 30px; height: 30px; margin: 0 auto; position: relative;"> <div style="position: absolute; top: 5px; left: 5px;">•</div> <div style="position: absolute; bottom: 5px; left: 5px;">•</div> </div>

SECTION A

Answer questions 1–30 on the answer sheet.

1. A long-distance athlete runs from point P to point Q and then jogs to point R.

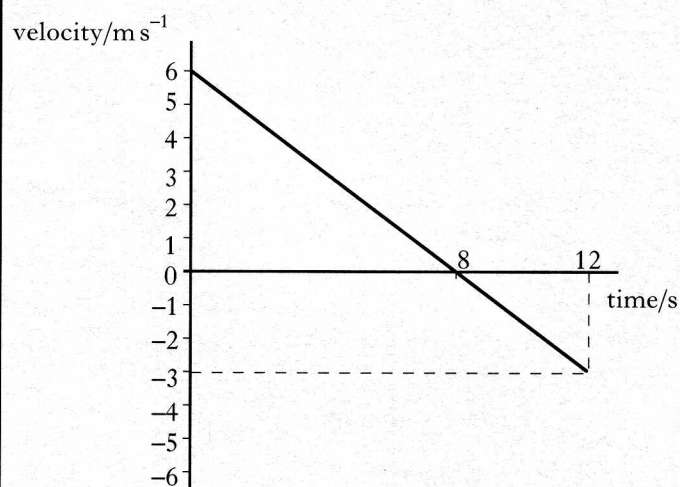


She takes 20 minutes to run from P to Q and then a further 40 minutes to jog from Q to R.

Which row in the following table correctly gives her average speed and her average velocity for the whole journey from P to R?

	Average speed	Average velocity
A	7.0 km h^{-1}	5.0 km h^{-1} on a bearing of 143°
B	7.0 km h^{-1}	7.0 km h^{-1} on a bearing of 127°
C	7.0 km h^{-1}	5.0 km h^{-1} on a bearing of 127°
D	5.0 km h^{-1}	7.0 km h^{-1} on a bearing of 127°
E	5.0 km h^{-1}	5.0 km h^{-1} on a bearing of 143°

2. The velocity-time graph for an object travelling along a straight line is shown below.

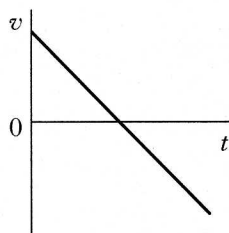


The displacement of the object during the first 12 seconds is

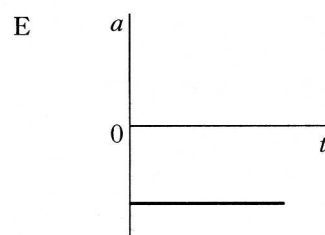
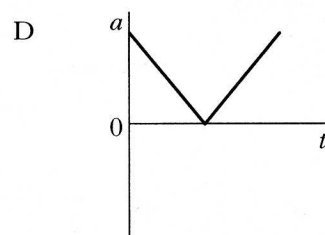
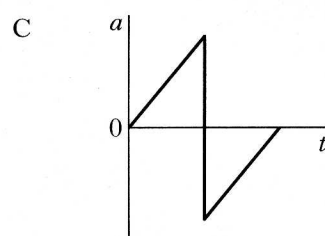
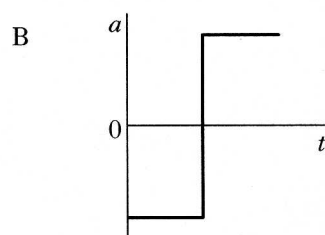
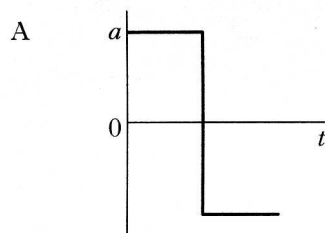
- A 18 m
- B 24 m
- C 30 m
- D 36 m
- E 54 m.

[Turn over

3. The velocity-time graph for an object travelling in a straight line is shown below.

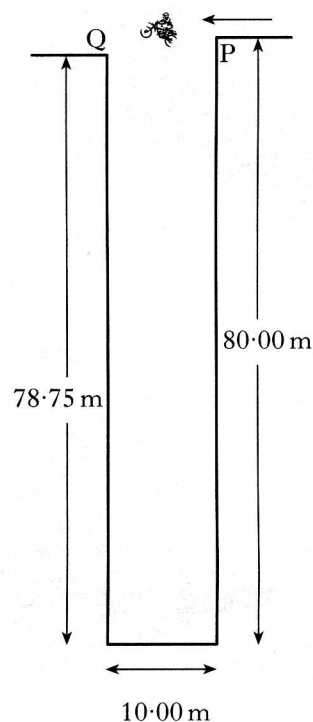


Which one of the following is the corresponding acceleration-time graph?



4. In the equation $s = ut + \frac{1}{2}at^2$ for an object moving in a straight line with a uniform acceleration "a", the term "ut" represents
- A the initial velocity of the object
 - B the initial acceleration of the object
 - C the velocity of the object after t seconds
 - D the acceleration of the object after t seconds
 - E the displacement of the object after t seconds if the acceleration is zero.

5. A motorcycle stunt involves crossing a ravine from P to Q. The motorcycle is travelling horizontally when it leaves point P.



Neglecting air resistance and taking the acceleration due to gravity to be 10 m s^{-2} , the time taken to cross the ravine from P to Q is

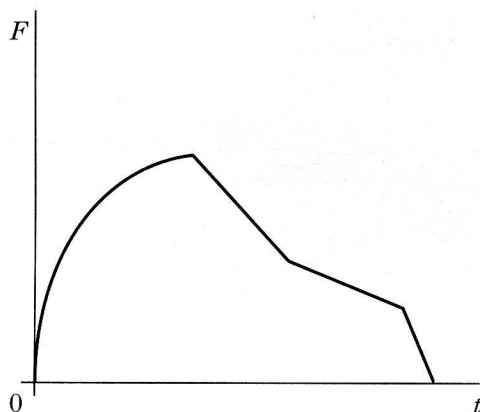
- A 0.125 s
- B 0.25 s
- C 0.5 s
- D 1.0 s
- E 4.0 s.

6. A crane on an oil-rig is used to raise a sunken buoy from the seabed. The weight of the buoy is 4900 N and the buoyancy force (upthrust) acting on it is 1000 N. When the buoy is being raised vertically at a constant speed, a force of 800 N acts on it due to water resistance.

What is the size of the force which the vertical cable applies to the buoy?

- A 200 N
- B 1800 N
- C 3100 N
- D 4700 N
- E 6700 N

7. The graph below shows how the force, F , exerted on an object varies with time t .



The area under the graph represents the object's change of

- A acceleration
- B velocity
- C momentum
- D kinetic energy
- E potential energy.

8. A spacecraft of mass 1200 kg has landed on a planet where the gravitational field strength is 5 N kg^{-1} . The spacecraft rests on three pads, each of contact area 0.5 m^2 . The pressure exerted by these three pads on the surface of the planet is

- A $8.0 \times 10^2 \text{ Pa}$
- B $4.0 \times 10^3 \text{ Pa}$
- C $7.8 \times 10^3 \text{ Pa}$
- D $9.0 \times 10^3 \text{ Pa}$
- E $1.2 \times 10^4 \text{ Pa}$.

9. A girl wrote the following statements in her physics notebook.

- I The pressure of a fixed mass of gas varies inversely as its volume, provided the temperature of the gas remains constant.
- II The pressure of a fixed mass of gas varies directly as its kelvin temperature, provided the volume of the gas remains constant.
- III A temperature **change** of 20°C in a gas is the same as a temperature **change** of 293 K.

Which of the above statements is/are correct?

- A I only
- B II only
- C III only
- D I and II only
- E II and III only

10. On a cold morning, a motorist checks the pressure of the air in one of her car tyres. It is found to be $3.0 \times 10^5 \text{ Pa}$ at a temperature of 2°C .

After a long run on a motorway, the temperature of the air in the tyre rises to 57°C . The volume of the air in the tyre remains constant and no air escapes.

Which row in the following table gives the correct value of the final pressure of the air in the tyre and a correct statement about the final density of the air in the tyre compared to the initial density?

	<i>Final pressure of air</i>	<i>Final density of air</i>
A	$8.6 \times 10^6 \text{ Pa}$	greater
B	$8.6 \times 10^6 \text{ Pa}$	same
C	$8.6 \times 10^6 \text{ Pa}$	less
D	$3.6 \times 10^5 \text{ Pa}$	same
E	$3.6 \times 10^5 \text{ Pa}$	less

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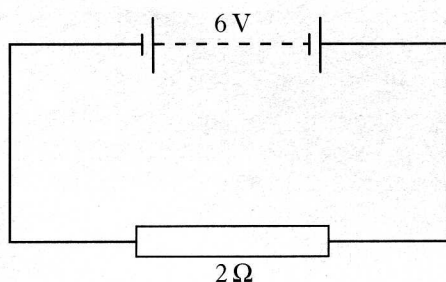
11. A pupil is given three resistors of values $2.0\ \Omega$, $3.0\ \Omega$ and $6.0\ \Omega$.

She is told to connect **all three** resistors together.

What are the values of the smallest possible resistance and the largest possible resistance which she could obtain by connecting all three resistors?

	<i>Smallest resistance/Ω</i>	<i>Largest resistance/Ω</i>
A	1.0	36.0
B	1.0	11.0
C	2.0	36.0
D	2.0	11.0
E	4.0	36.0

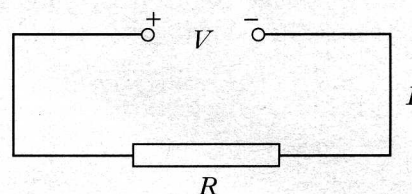
12. In the following circuit, the battery has an e.m.f. of 6 V and negligible internal resistance.



The energy required to move one coulomb of charge round this circuit is

- A 3 J
- B 6 J
- C 12 J
- D 18 J
- E 72 J.

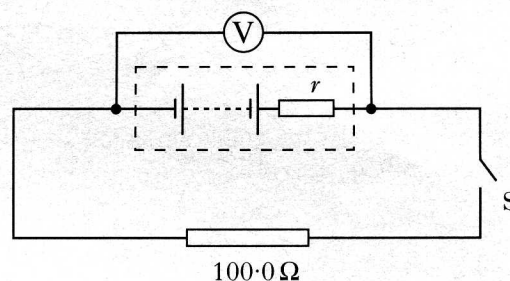
13. When the potential difference across a heater of resistance R ohms is V volts, there is a current of I amperes in the heater.



The power of the heater, in watts, is given by

- A IR
- B $\frac{V^2}{R}$
- C $\frac{V}{I}$
- D V^2R
- E IR^2 .

14. A pupil sets up the following circuit to measure the internal resistance r of a battery.

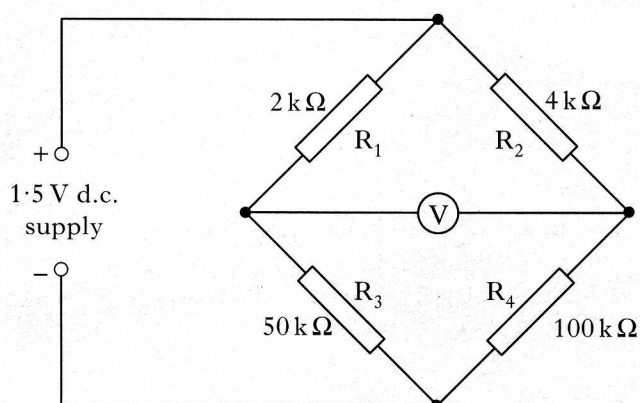


The reading on the voltmeter is 12.0 V when switch S is open. The reading drops to 10.0 V when switch S is closed.

The internal resistance of the battery is

- A $0.00\ \Omega$
- B $0.05\ \Omega$
- C $16.7\ \Omega$
- D $20.0\ \Omega$
- E $100.0\ \Omega$.

15. A balanced Wheatstone bridge circuit is set up as shown.

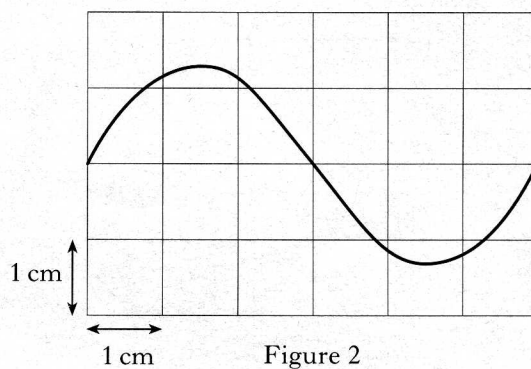
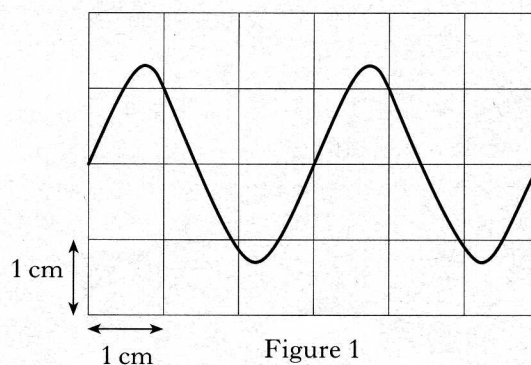


Which of the following changes will cause the Wheatstone bridge to be changed to an out-of-balance condition?

- I Doubling the value of R_1 and doubling the value of R_2
 - II Doubling the value of R_1 and doubling the value of R_4
 - III Doubling the voltage of the supply
- A I only
 B II only
 C I and II only
 D II and III only
 E I, II and III

16. An alternating voltage produces a trace on an oscilloscope screen as shown in Figure 1. The boxes on the screen measure $1\text{ cm} \times 1\text{ cm}$.

The time-base setting of the oscilloscope is 50 milliseconds per centimetre.

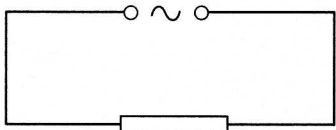


How should the oscilloscope controls be adjusted to change the trace on the screen to that shown in Figure 2?

	<i>Y-amplification</i>	<i>Time-base setting (in ms per cm)</i>
A	increased	100
B	unchanged	100
C	unchanged	25
D	increased	50
E	decreased	25

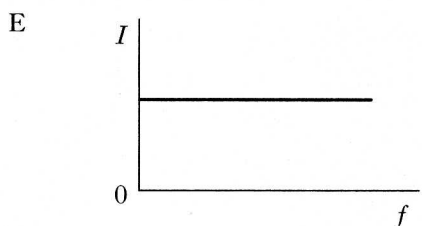
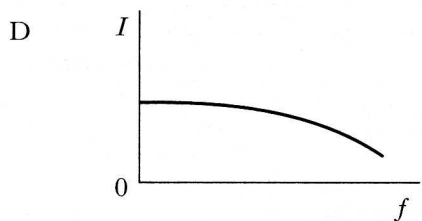
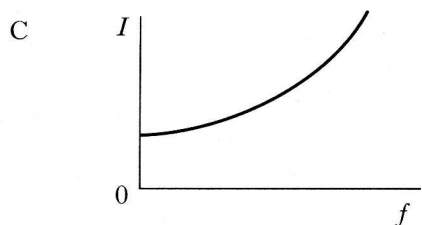
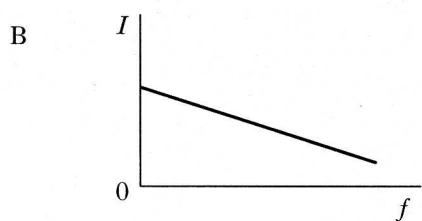
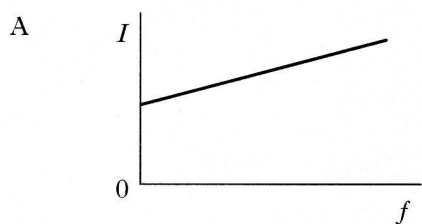
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17. A resistor is connected across a signal generator, as shown below.



The r.m.s. voltage of the signal generator remains constant.

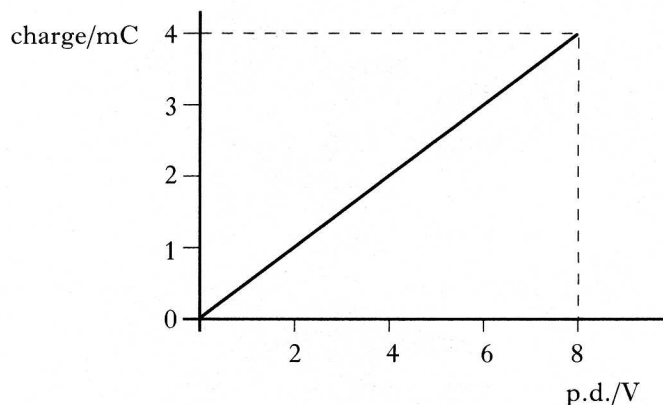
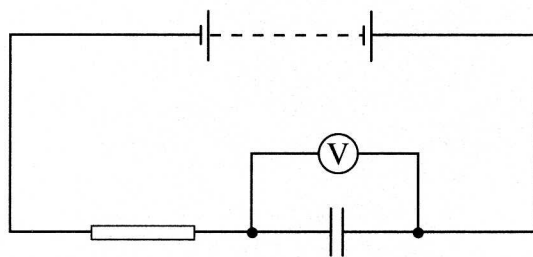
Which of the following graphs shows how the r.m.s. current I varies with frequency f in this circuit?



18. The farad is equivalent to the

- A volt per coulomb
- B ampere per volt
- C joule per coulomb
- D coulomb per volt
- E coulomb per joule.

19. In the following circuit, a capacitor is being charged up from a d.c. supply. The graph shows how the charge on the capacitor depends on the p.d. across the capacitor.



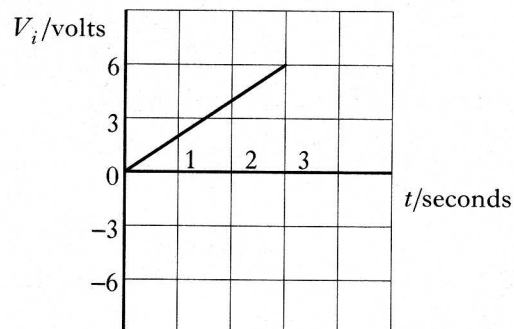
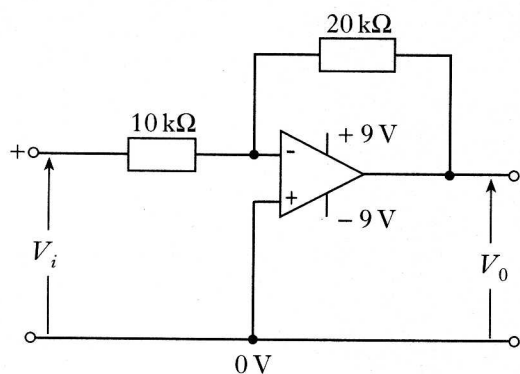
The energy stored in the capacitor when the p.d. across it is 8 V is

- A 0.25 mJ
- B 0.5 mJ
- C 16 mJ
- D 32 mJ
- E 128 mJ.

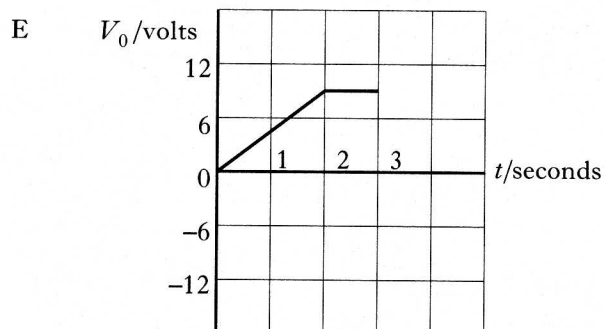
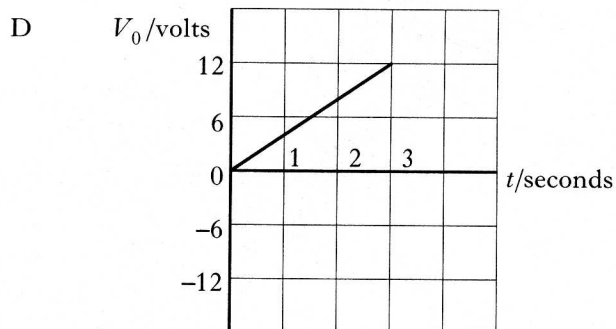
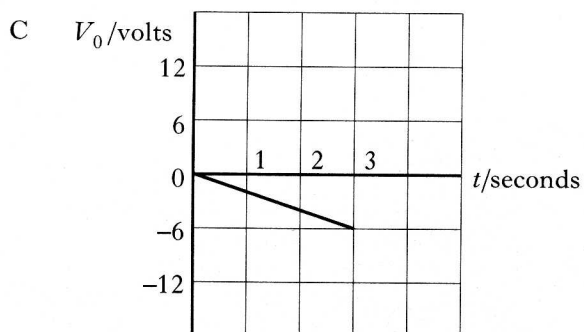
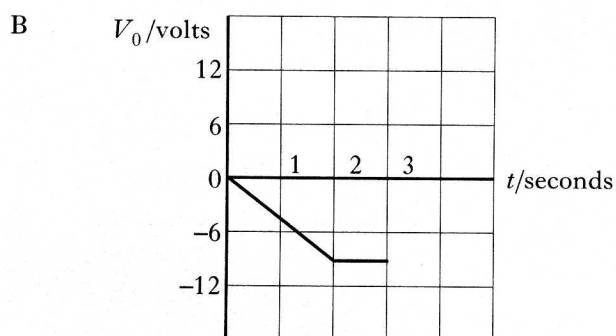
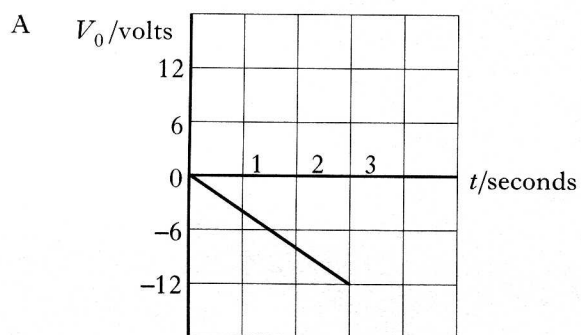
20. The following operational amplifier circuit is set up.

Supply voltages of +9 V and -9 V are used for the op-amp.

The input voltage V_i is adjusted so that it rises steadily from 0 V to 6 V in 3 seconds, as shown in the graph.

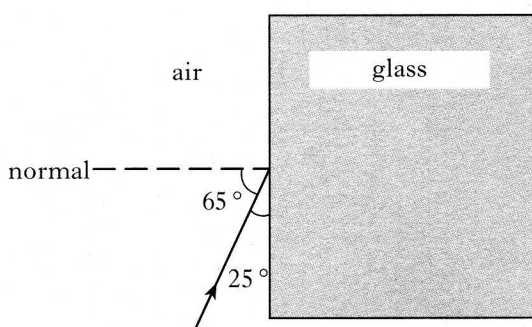


Which of the following graphs shows the correct variation of output voltage V_0 against time?



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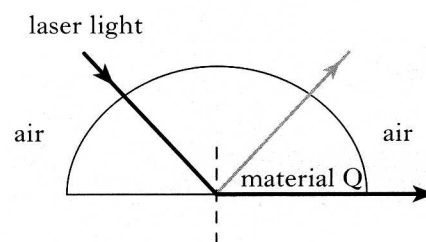
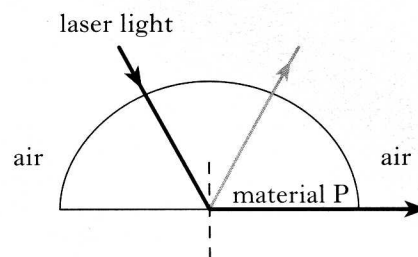
21. A ray of monochromatic light of frequency 6.0×10^{14} Hz in air is incident upon a block of glass of refractive index 1.5, as shown below.



Which row in the table below gives the angle of refraction and the frequency of the light in the block of glass?

	Angle of refraction in glass	Frequency in glass/ Hz
A	37°	6.0×10^{14}
B	37°	4.0×10^{14}
C	16°	6.0×10^{14}
D	16°	4.0×10^{14}
E	37°	9.0×10^{14}

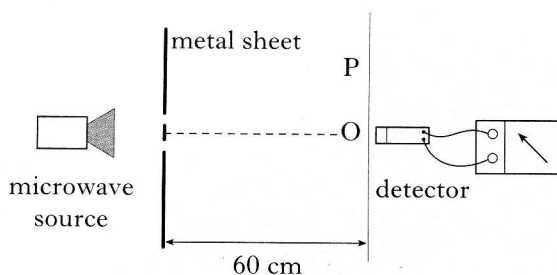
22. A student uses a beam of laser light to investigate critical angle. He uses two semicircular blocks made from different transparent materials, P and Q. In the following diagrams, the incident rays of light are shown at their critical angles.



Which of the following statements is/are true?

- I Material P has a higher refractive index than material Q.
 - II The wavelength of the laser light is longer inside material P than inside material Q.
 - III The laser light travels at the same speed inside materials P and Q.
- A I only
 B II only
 C III only
 D I and II only
 E I, II and III

23. Microwaves with a wavelength of 3 cm in air are sent towards two slits in a metal sheet, as shown below.



With the detector at a distance of 60 cm from the metal sheet, a position of maximum intensity is obtained at the central position O.

The detector is moved up from position O until the next maximum is obtained at position P.

A second microwave source with a different wavelength then replaces the first source. It produces its first MINIMUM at position P.

The wavelength of the second microwave source is

- A 1.5 cm
- B 2.5 cm
- C 4.5 cm
- D 6.0 cm
- E 20.0 cm.

24. Which row in the following table gives the approximate wavelengths of red, green and blue light in nanometres?

	Red light/nm	Green light/nm	Blue light/nm
A	700	550	480
B	700	480	550
C	900	700	550
D	700	550	300
E	480	550	700

25. In the following passage, three words have been replaced by the letters X, Y and Z.

"The intensity of light incident on a surface is equal to the X per square metre. The intensity is Y proportional to the square of the distance from a point source of light, which means that, if the distance from the source is Z, the new intensity is a quarter of the initial value."

Which of the following gives the correct words for X, Y and Z?

	X	Y	Z
A	energy	directly	doubled
B	energy	inversely	doubled
C	power	directly	quartered
D	power	inversely	doubled
E	power	inversely	quadrupled

26. Ultraviolet radiation is incident on a zinc plate. Photoelectrons with a certain maximum kinetic energy are released from the zinc. The intensity of the ultraviolet radiation is now increased.

What happens to the maximum kinetic energy of the photoelectrons and the rate at which they are released?

	Maximum kinetic energy of the photoelectrons	Rate at which photoelectrons are released
A	increases	increases
B	decreases	increases
C	increases	remains the same
D	remains the same	increases
E	remains the same	remains the same

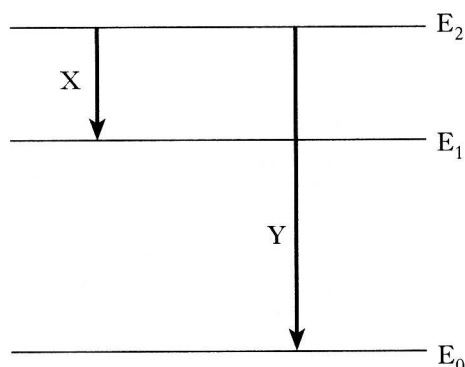
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27. The minimum energy required to eject an electron from a certain metal is $3.0 \times 10^{-19} \text{ J}$. Light of frequency $4.8 \times 10^{14} \text{ Hz}$ is incident on this metal.

Which of the following statements is correct?

- A Electrons will not be ejected from the metal.
- B Electrons will be ejected with 0 J of kinetic energy.
- C Electrons will be ejected with $1.8 \times 10^{-20} \text{ J}$ of kinetic energy.
- D Electrons will be ejected with $3.2 \times 10^{-19} \text{ J}$ of kinetic energy.
- E Electrons will be ejected with $6.2 \times 10^{-19} \text{ J}$ of kinetic energy.

28. Part of the energy level diagram for a certain atom is shown below.



A student makes the following statements.

- I Photons of higher frequency will be emitted during transition Y than during transition X.
- II Photons of longer wavelength will be emitted during transition X than during transition Y.
- III When an electron is in the lowest energy level, the atom is ionised.

Which of the above statements is/are true?

- A I only
- B I and II only
- C I and III only
- D II and III only
- E I, II and III

29. In a nuclear reactor, Uranium 239 decays into nuclide X by emitting a beta particle, as shown in the following reaction.



Which row in the table gives the correct information about the nuclide X?

	Mass Number	Atomic Number
A	235	90
B	238	92
C	239	92
D	239	93
E	239	91

30. During an experiment to measure the specific heat capacity of a liquid, the relationship $V I t = c m \Delta T$ is used.

The following quantities are measured.

$$V = 12.0 \pm 0.1 \text{ V}$$

$$I = 4.2 \pm 0.1 \text{ A}$$

$$t = 300 \pm 1 \text{ s}$$

$$m = 500 \pm 2 \text{ g}$$

$$\Delta T = 15 \pm 1 ^\circ\text{C}$$

Which quantity will contribute the largest uncertainty to the final answer for the specific heat capacity, c ?

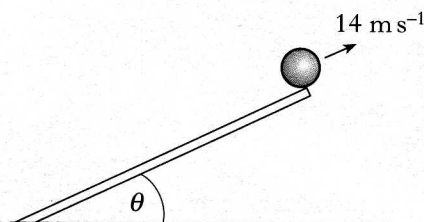
- A Voltage
- B Current
- C Time
- D Mass
- E Temperature change

SECTION B

Write your answers to questions 31 to 37 in the answer book.

Marks

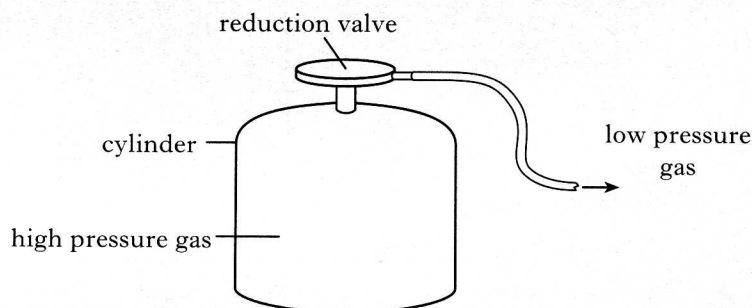
31. A ball is rolled up a slope so that it is travelling at 14 m s^{-1} as it leaves the end of the slope.



- (a) The slope is set so that the angle to the horizontal, θ , is 30° .
Calculate the vertical component of the velocity of the ball as it leaves the slope.
- (b) The slope is now tilted so that the angle to the horizontal, θ , is increased. The ball is rolled so that it still leaves the end of the slope at 14 m s^{-1} .
Describe and explain what happens to the maximum height reached by the ball.

3

32. Gas is often stored in cylinders at high pressure. The pressure of the gas must be reduced by a reduction valve before the gas can be used.



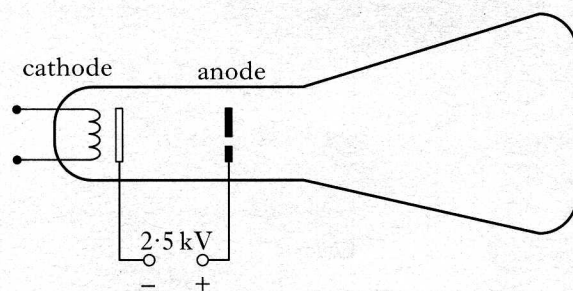
The pressure of the gas in the cylinder is $20 \times 10^5 \text{ Pa}$. The pressure of the gas as it leaves the reduction valve is $4 \times 10^5 \text{ Pa}$.

Gas with a volume of 0.01 m^3 enters the reduction valve from the cylinder. What is the volume of this gas when it leaves the reduction valve, assuming that the temperature of the gas does not change?

2

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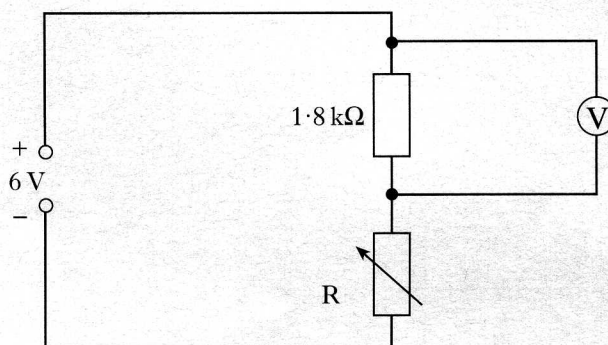
33. The diagram shows an arrangement which is used to accelerate electrons. The potential difference between the cathode and the anode is 2.5 kV .



Assuming that the electrons start from rest at the cathode, calculate the speed of an electron just as it reaches the anode.

3

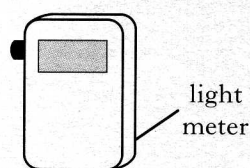
34. A $1.8 \text{ k}\Omega$ resistor and a variable resistor, R , are connected to a 6 V d.c. supply as shown. The supply has negligible internal resistance. A voltmeter is used to measure the potential difference across the $1.8 \text{ k}\Omega$ resistor.



- (a) Calculate the potential difference across the $1.8 \text{ k}\Omega$ resistor when the variable resistor, R , has a value of $1.2 \text{ k}\Omega$.
- (b) The resistance of the variable resistor, R , is increased. Explain why the reading on the voltmeter decreases.

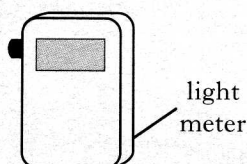
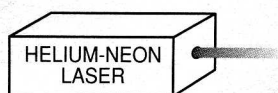
3

35. (a) A light meter is used to measure the intensity of light from a small lamp.



At a distance of 1.5 m from the lamp, the intensity of the light is 0.60 W m^{-2} . What is the intensity at a distance of 4.5 m from the lamp?

- (b) At a distance of 1.5 m from a laser, the intensity of the laser light is 400 W m^{-2} .

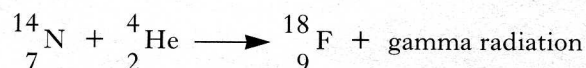


What is the intensity of the laser light at a distance of 4.5 m from the laser? Justify your answer.

4

36. Energy is released from stars as a result of nuclear reactions.

One of these reactions is represented by the statement given below.



- (a) What type of nuclear reaction is described by this statement?
 (b) Explain why this reaction results in the release of energy. You should make reference to an equation in your explanation.

3

37. When introducing optoelectronics to a class, a Physics teacher writes:

“One of the important factors affecting *photoelectric emission* from a metal is the *threshold frequency* for the metal”.

Explain the meaning of the terms:

- (a) photoelectric emission;
 (b) threshold frequency.

2

[END OF QUESTION PAPER]