perfectpapers

[PHY(H)10]

NATIONAL QUALIFICATIONS 2010

TIME: 2 hours 30 minutes

PHYSICS
HIGHER
Paper 1
Units 1 and 2

Estimate Examination Paper

Read Carefully

1. All questions should be attempted.

Section A (questions 1 to 20)

2. Check that the answer sheet is for Higher Physics (Section A).
3. Answer the questions numbered 1 to 20 on the answer sheet provided.
4. Fill in the details required on the answer sheet.
5. 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.
6. For each of the questions 1 to 20 there is only **one** correct answer and each is worth 1 mark.
7. Instructions as to how to record your answers to questions 1–20 are given on page three.

Section B (questions 21 to 28)

8. Answer questions numbered 21 to 28 in the answer book provided.
9. Fill in the details on the front of the answer book.
10. Enter the question number clearly in the margin of the answer book beside each of your answers to questions 21 to 28.
11. Care should be taken to give an appropriate number of significant figures in the final answers to calculations.

This paper must be withdrawn from candidates after any follow-up discussion of marks/grades awarded. This is to ensure the 'sight unseen' status of this paper is maintained for your centre and other schools/colleges during the diet of prelim examinations in 2009/2010. Submission of this test paper for Appeals purposes will assume that these conditions have been applied.

DATA SHEET
COMMON PHYSICAL QUANTITIES

Quantity	*Symbol*	*Value*	*Quantity*	*Symbol*	*Value*
Speed of light in Vacuum	c	$3{\cdot}00 \times 10^{8}$ m s^{-1}	Mass of electron	m_e	$9{\cdot}11 \times 10^{-31}$ kg
Magnitude of the charge on electron	e	$1{\cdot}60 \times 10^{-19}$ C	Mass of neutron	m_n	$1{\cdot}675 \times 10^{-27}$ kg
Gravitational acceleration on Earth	g	$9{\cdot}8$ m s^{-2}	Mass of proton	m_p	$1{\cdot}673 \times 10^{-27}$ kg
Planck's constant	h	$6{\cdot}63 \times 10^{-34}$ J s			

REFRACTIVE INDICES
The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

Substance	*Refractive index*	*Substance*	*Refractive index*
Diamond	2·42	Water	1·33
Crown glass	1·50	Air	1·00

SPECTRAL LINES

Element	*Wavelength*/nm	*Colour*
Hydrogen	656	Red
	486	Blue-green
	434	Blue-violet
	410	Violet
	397	Ultraviolet
	389	Ultraviolet
Sodium	589	Yellow

Element	*Wavelength*/nm	*Colour*
Cadmium	644	Red
	509	Green
	480	Blue

Lasers

Element	*Wavelength*/nm	*Colour*
Carbon dioxide	9550 10590 }	Infrared
Helium-neon	633	Red

PROPERTIES OF SELECTED MATERIALS

Substance	*Density*/ kg m^{-3}	*Melting Point*/ K	*Boiling Point*/ K
Aluminium	$2{\cdot}70 \times 10^{3}$	933	2623
Copper	$8{\cdot}96 \times 10^{3}$	1357	2853
Ice	$9{\cdot}20 \times 10^{2}$	273	. . . .
Sea Water	$1{\cdot}02 \times 10^{3}$	264	377
Water	$1{\cdot}00 \times 10^{3}$	273	373
Air	1·29	. . . .	. . . .
Hydrogen	$9{\cdot}0 \times 10^{-2}$	14	20

The gas densities refer to a temperature of 273 K and a pressure of $1{\cdot}01 \times 10^{5}$ Pa.

SECTION A

For questions 1 to 20 in this section of the paper the answer to each question is either A, B, C, D or E. Decide what your answer is, then, using pencil, put a horizontal line in the space provided—see the example below.

EXAMPLE

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

A ampere

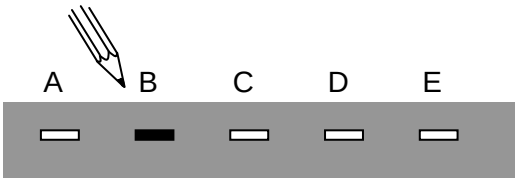
B kilowatt-hour

C watt

D coulomb

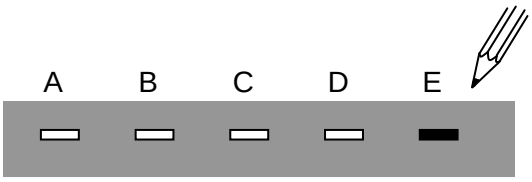
E volt.

The correct answer is **B** - kilowatt-hour. The answer **B** has been clearly marked with a horizontal line (see below).



Changing an answer

If you decide to change your answer, carefully erase your first answer and, using your pencil, fill in the answer you want. The answer below has been changed to **E**.



[Turn over

SECTION A

Answer questions 1–20 on the answer sheet.

1. Which of the following combinations contains one scalar quantity and two vector quantities?

A Acceleration, displacement, force

B Acceleration, energy, force

C Acceleration, force, velocity

D Distance, energy, force

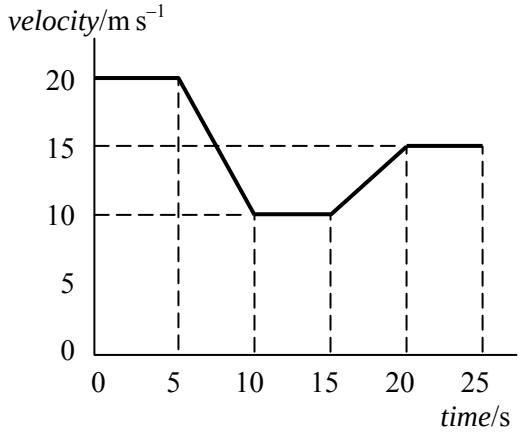
E Energy, force, temperature

2. A ship sails due south for 4 km, then due west for a further 3 km. The journey takes a total of 30 minutes.

Which row in the table below shows the correct magnitudes of the ship's average speed and average velocity during the journey?

	Average speed /km h^{-1}	*Average velocity* /km h^{-1}
A	5	7
B	8	6
C	10	14
D	14	10
E	14	14

3. The velocity-time graph of a moving object is shown below.



Which of the following statements is/are true?

I During the first five seconds, the object has balanced forces acting on it.

II After five seconds, the object is 100 m away from its starting position.

III Between five and ten seconds, there is an unbalanced force acting on the object, in the opposite direction to the object's motion.

A I only

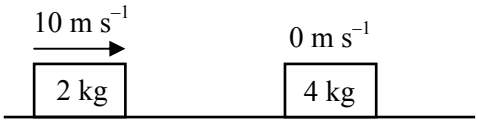
B II only

C I and III only

D II and III only

E I, II and III

4. Two objects are free to slide on a frictionless surface. A 2 kg object with a velocity of 10 m s^{-1} collides with a stationary 4 kg object as shown below.



After the collision their masses and velocities are as shown below.

Which row in the table below is correct?

	Kinetic energy of system	*Type of collision*
A	not conserved	inelastic
B	not conserved	elastic
C	not conserved	explosion
D	conserved	elastic
E	conserved	inelastic

5. A space probe, of mass $2{\cdot}0 \times 10^3$ kg, is launched from a space station of mass $3{\cdot}0 \times 10^4$ kg. The speed of the space probe relative to the point of launch is 6·0 m s^{-1}.

The speed of the space station relative to the point of launch is

A 0·003 m s^{-1}

B 0·11 m s^{-1}

C 0·40 m s^{-1}

D 15 m s^{-1}

E 90 m s^{-1}.

6. A bottle of medication contains 20 capsules. The mass of the full bottle is 208 g. The mass of the bottle when it is empty is 40 g. The density of the medication is $1{\cdot}20 \times 10^3$ kg m^{-3}.

The volume of one capsule is

A $1{\cdot}01 \times 10^{-7}$ m^3

B $7{\cdot}00 \times 10^{-6}$ m^3

C $2{\cdot}02 \times 10^{-5}$ m^3

D $1{\cdot}40 \times 10^{-4}$ m^3

E $10{\cdot}1$ m^3.

7. A block of a lightweight material is placed in a tank of water and is observed to sink so that its bottom surface is a depth of 50 mm below the surface.

Which of the following statements is/are true?

I The pressure of the water on the top and bottom surfaces of the block is equal.

II The same block placed in a more dense liquid floats nearer the surface.

III A more dense block of the same size floats at the same depth.

A I only.

B II only.

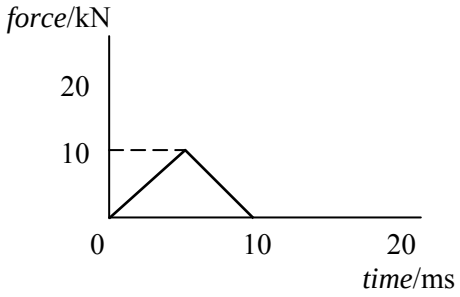
C I and II only

D I and III only

E I, II and III

[Turn over

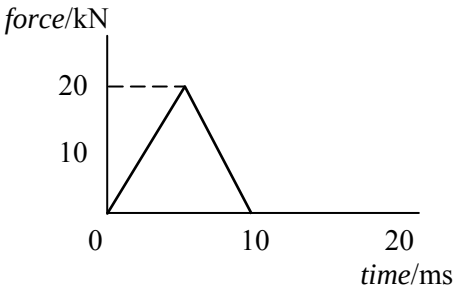
8. The force exerted on a steel beam during a high impact collision test is shown below.



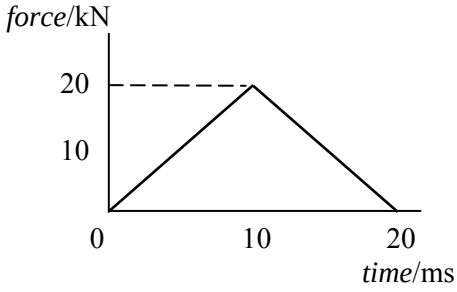
The beam is now surrounded by foam padding and the test is repeated.

Which of the graphs opposite may be observed?

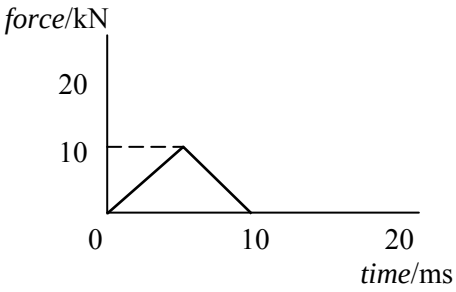
A



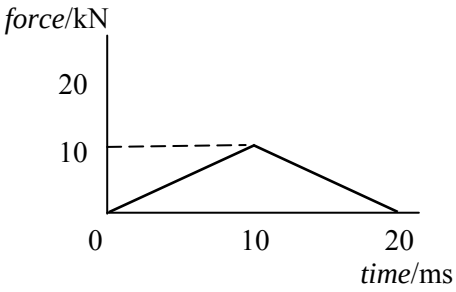
B



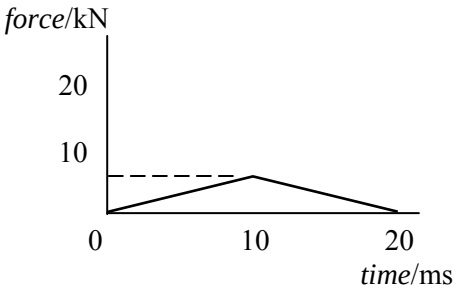
C



D



E



9. A piston can be moved vertically to change the volume of a container. When the gas inside is at a pressure of 120 kPa, its volume is 5·0 m^3.

Assuming that temperature remains constant, which of the following are possible values for the volume and pressure inside the container?

A 180 kPa, 6·0 m^3

B 150 kPa, 4·0 m^3

C 125 kPa, 4·0 m^3

D 100 kPa, 4·5 m^3

E 100 kPa, 6·5 m^3

10. An electron is accelerated by a uniform electric field between two plates. The potential difference across the plates is 250 V.

The energy gained by the electron is

A $2{\cdot}28 \times 10^{-28}$ J

B $6{\cdot}40 \times 10^{-22}$ J

C $2{\cdot}00 \times 10^{-17}$ J

D $4{\cdot}00 \times 10^{-17}$ J

E $1{\cdot}56 \times 10^{21}$ J.

11. An a.c. supply has a frequency of 50 Hz. The r.m.s current being drawn from it is 1·50 A.

The peak current is

A 0·030 A

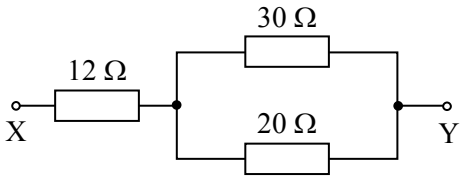
B 1·06 A

C 2·12 A

D 33·3 A

E 35·4 A.

12. Three resistors are arranged as shown.



The resistance between X and Y is

A 6·0 Ω

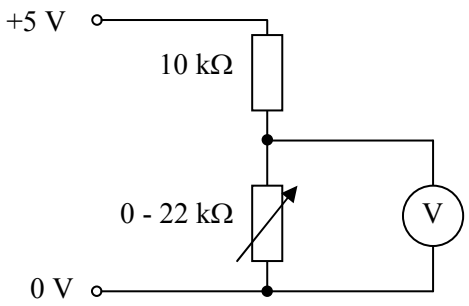
B 12 Ω

C 14 Ω

D 24 Ω

E 62 Ω.

13. A potential divider circuit is set up as shown.



The maximum possible reading on the voltmeter is

A 0 V

B 1·6 V

C 2·5 V

D 3·4 V

E 5·0 V.

[Turn over

14. Which of the following statements is/are true?

I The terminal potential difference obtained from a cell decreases as the current drawn from it increases.

II The e.m.f of a cell decreases as the current drawn from it increases.

III The internal resistance of a cell decreases as a current is drawn from it increases.

A I only

B II only

C III only

D I and III only

E I, II and III

15. The potential difference across a capacitor is 2·40 V when the charge stored in it is 360 μC.

The capacitance of the capacitor is

A $7{\cdot}50 \times 10^{-5}$ F

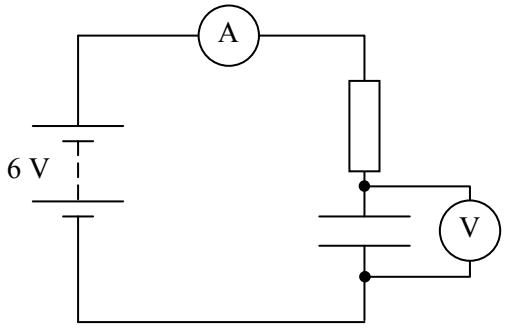
B $1{\cdot}50 \times 10^{-4}$ F

C $1{\cdot}04 \times 10^{-3}$ F

D $1{\cdot}50 \times 10^{-1}$ F

E $6{\cdot}67 \times 10^{3}$ F.

16. A capacitor is charged using the circuit shown.



Which of the following statements is/are true?

I The reading on the voltmeter increases until it reads 6 V.

II The reading on the ammeter increases as the capacitor charges up.

III Replacing the resistor with one of a smaller value causes the capacitor to become fully charged in a shorter period of time.

A I only

B II only

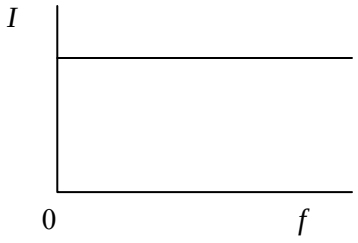
C I and III only

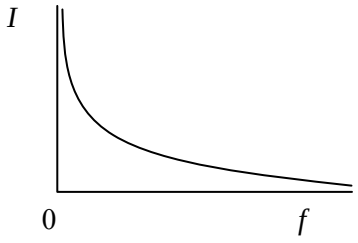
D II and III only

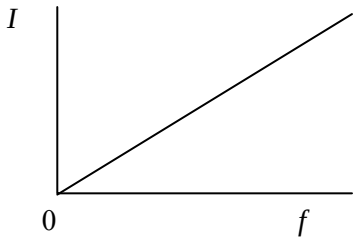
E I, II and III

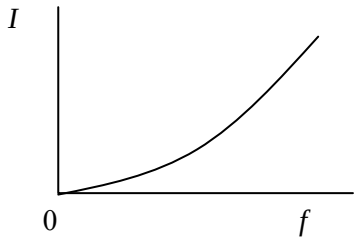
17. A signal generator produces an a.c. signal of constant amplitude and variable frequency. It is connected to a resistor and ammeter in series.

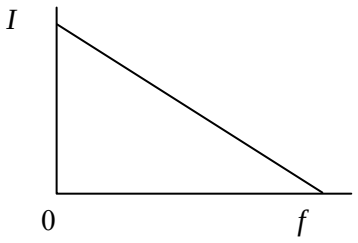
Which of the following graphs shows the relationship between the current in the circuit and the frequency of the signal?

A 

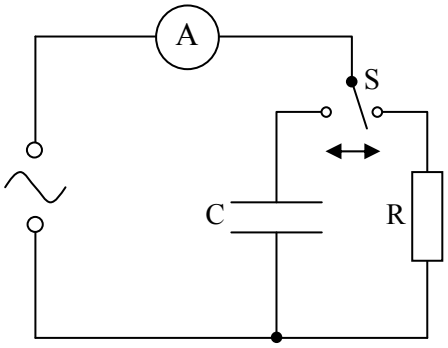
B 

C 

D 

E 

18. In the circuit shown the signal generator is set so that the ammeter gives the same reading when the two-way switch S is connected to either the capacitor C or the resisitor R.

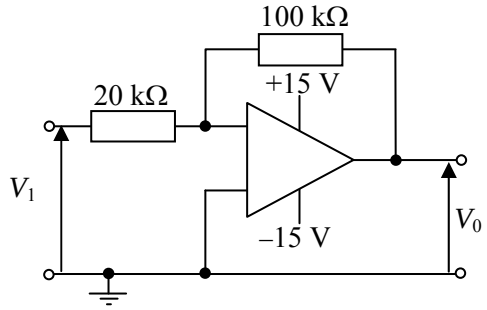


The frequency of the signal generator is then halved. Which row in the table correctly shows how the ammeter reading is affected by connecting the switch to capacitor C and resistor R in turn?

	Switch connected to capacitor	*Switch connected to resistor*
A	no change	no change
B	halves	no change
C	no change	halves
D	doubles	no change
E	doubles	doubles

[Turn over

19. An operational amplifier circuit is shown in the diagram below.



Which of the following statements is/are true?

I The op-amp is in inverting mode.

II V_0 is five times greater and opposite in sign to V_1.

III Ideally, the op-amp would have an infinite input 'resistance'.

A I only

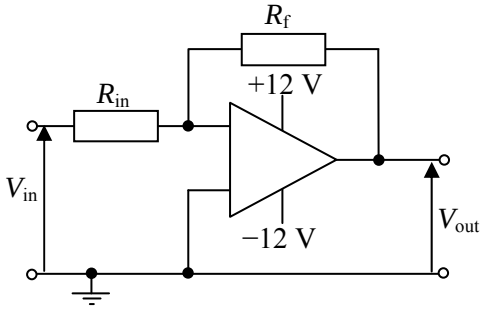
B II only

C I and III only

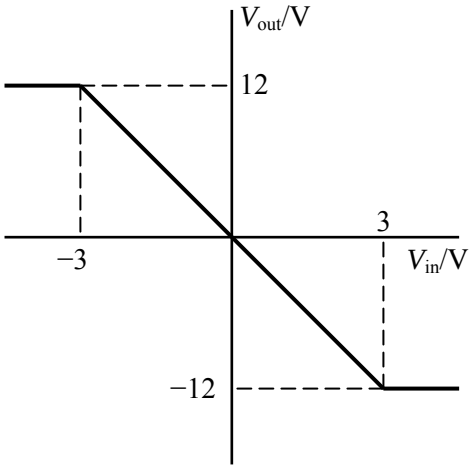
D II and III only

E I, II and III

20. An op-amp is connected in a circuit.



A graph of V_{out} against V_{in} for this circuit is shown.



Which pair of resistors, R_{in} and R_f, produces this graph?

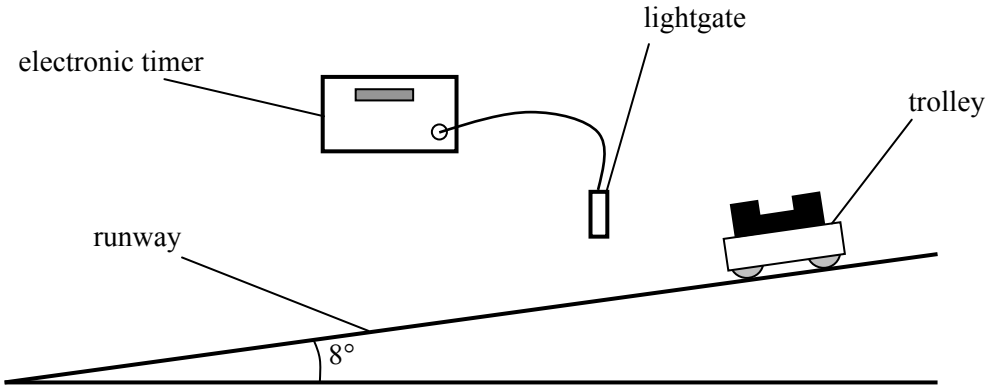
	R_{in}/kΩ	R_f/kΩ
A	1·0	12·0
B	3·0	12·0
C	12·0	3·0
D	4·0	12·0
E	12·0	4·0

SECTION B

Write your answers to questions 21–28 in the answer book.

Marks

21. An experiment to measure the acceleration of a trolley down an inclined runway is conducted using the apparatus shown.



(*a*) Explain how the electronic timer calculates the acceleration of the trolley once the lengths of the double masks have been entered into the timer. **3**

(*b*) The inclined runway is at an angle of 8° to the horizontal.

Calculate the acceleration of the trolley down the inclined runway. **2**

(*c*) A student uses the apparatus to take multiple readings of the acceleration of the trolley. The five values calculated by the electronic timer are:

1·27 m s^{-2}; 1·17 m s^{-2}; 1·27 m s^{-2}; 1·11 m s^{-2}; 1·10 m s^{-2}.

Calculate the mean acceleration and its absolute random uncertainty to an appropriate number of significant figures. **3**

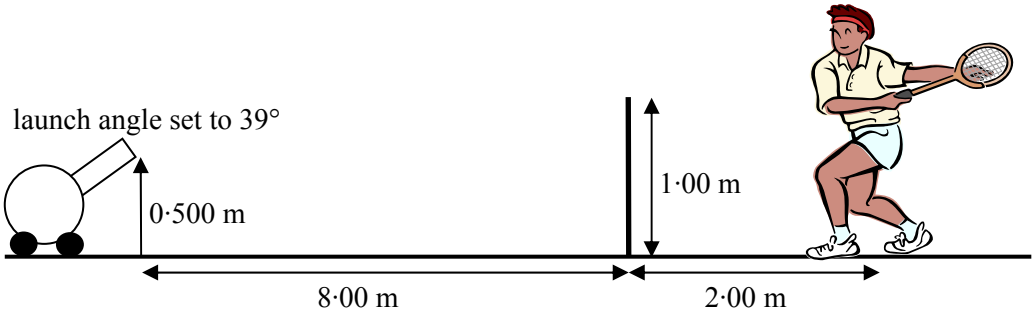
(*d*) Explain why the experimental mean value obtained and the theoretically predicted value differ. **1**

(9)

[Turn over

Marks

22. Whilst training, a tennis player uses an automated ball launcher to practice his volleys at the net. The ball launcher has variable settings for angle and speed. The court is arranged as shown in the diagram below.



(*a*) The ball takes 1·2 s to reach the player from the launcher.

Calculate the horizontal velocity of the ball. **2**

(*b*) By scale drawing, or otherwise, show that the initial vertical velocity of the ball as it leaves the launcher is 6·75 m s^{-1}. **2**

(*c*) The ball passes directly over the net 0·96 s after leaving the launcher.

Calculate the total vertical height of the ball from the ground as it passes over the net. **3**

(*d*) The mass of the tennis ball is 60 g. The instantaneous speed of the ball just before contact with the racquet is 10 m s^{-1}. Immediately after being hit, the ball's speed is 15 m s^{-1} and it is travelling in exactly the opposite direction.

(i) Calculate the impulse on the ball as it was struck. **2**

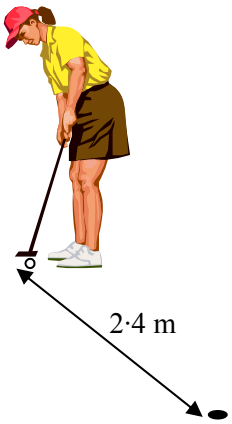
(ii) The racquet and ball are in contact for 20 ms.

Calculate the average force exerted on the ball by the racquet during this time. **2**

(11)

Marks

23. During a tournament, a golfer finds herself with a putt to win the competition. The golfer's ball is 2·4 m from the hole.



The green is completely horizontal.

The ball, which is initially at rest, is struck in such a way that momentum is conserved.

(*a*) The following information describe the ball and putter:

mass of the golf ball	=	46 g
mass of the putter head	=	550 g
velocity of the putter head immediately before the impact	=	0·50 ms^{-1}
velocity of the putter head immediately before the impact	=	0·45 ms^{-1}

Calculate the velocity of the ball immediately after the impact. **2**

(*b*) The ball rolls toward the hole, but comes to a halt 200 mm short of the hole.

(i) Calculate the average acceleration of the ball as it moved toward the hole. **3**

(ii) Calculate the magnitude and direction of the average frictional force acting against the ball as it rolled. **2**

(iii) Explain why the acceleration and frictional forces calculated above are considered to be averages over this distance. **1**

(7)

[Turn over

Marks

24. An air tight, rigid, plastic container is placed inside a freezer compartment of a fridge in order to preserve the food inside. The container is sealed at a temperature of 20°C at standard atmospheric pressure. The freezer compartment is held at a temperature of – 4°C by its cooling system.

(*a*) (i) Calculate the pressure of the air inside the sealed container once it cools to – 4°C. **2**

(ii) Using the kinetic model of gases, explain why the air pressure inside the container falls as the temperature drops. **2**

(iii) State the effect freezing the container has on the average density of its contents. **1**

(*b*) The lid on the container is circular and has a radius of 0·050 m.

Calculate the unbalanced force acting on the lid when the air pressure inside the container is 99·7 kPa. **4**

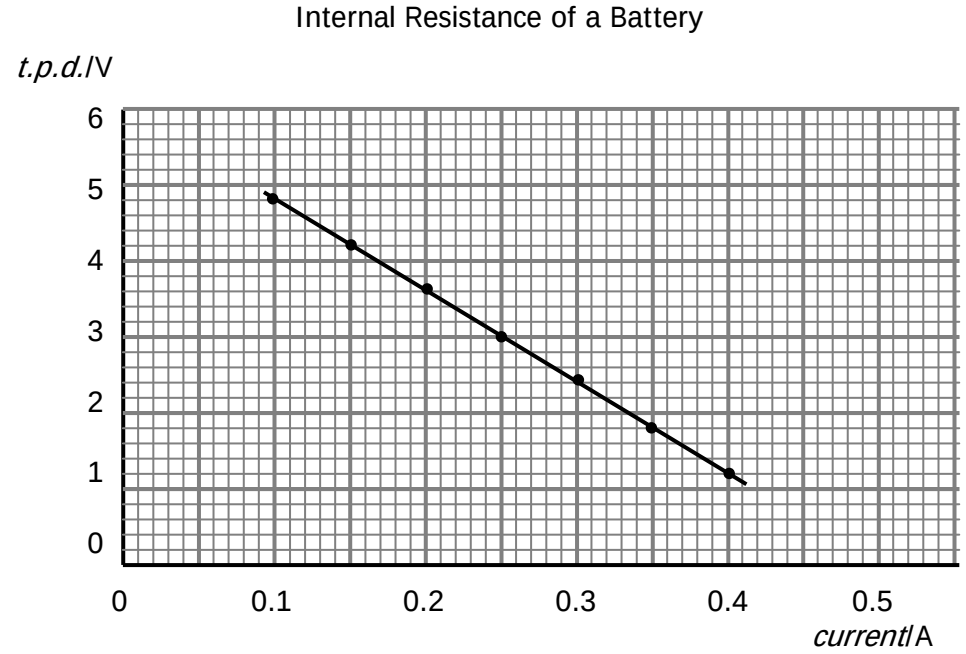
(9)

Marks

25. An experiment investigating terminal potential difference (t.p.d.) and electromotive force (e.m.f.) of a battery is to be conducted.

(*a*) Describe an experiment which could be used to determine the internal resistance of the battery. Your answer should include a suitable circuit diagram and what measurements should be taken. **2**

(*b*) A graph of the results of such an experiment is given below.



Equation of line of best fit: y = -12.0x + 6.0

State:

(i) the e.m.f. of the battery; **1**

(ii) the internal resistance of the battery. **1**

(*c*) (i) The same battery is now connected to a 470 Ω resistor.

Calculate the "lost volts" in the battery. **3**

(ii) This circuit is left connected for one hour.

Assuming the current in the circuit remains constant, calculate how much energy is 'lost' in the battery during this time. **2**

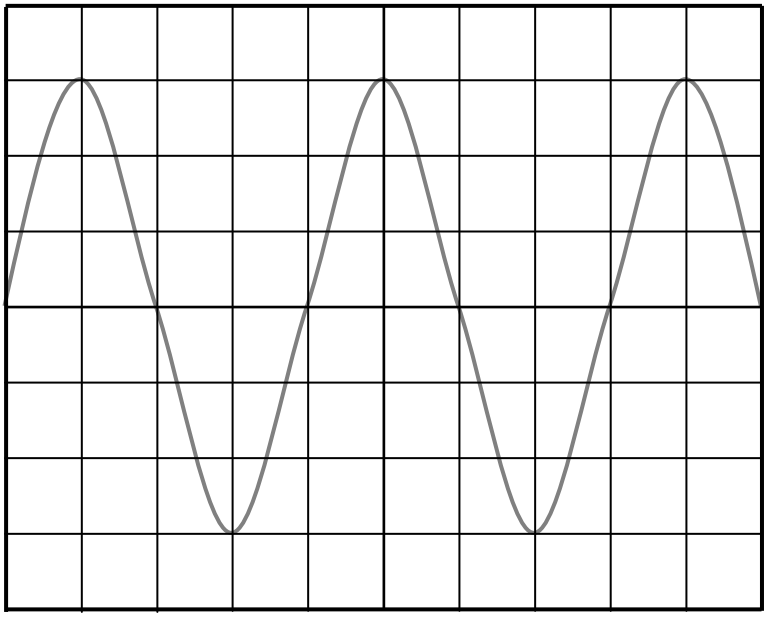
(iii) Explain what happens to this 'lost' energy. **1**

(10)

[Turn over

Marks

26. An investigation into the output produced by a basic model wind turbine uses small desktop fan is used as a source of 'wind'. The output of the wind turbine is connected to an oscilloscope. The trace observed and the oscilloscope settings are shown in the diagram below.



Oscilloscope settings: Time base = 10 ms/div, Y-gain = 0·2 V/div

(*a*) From the information on the diagram, calculate:

(i) the frequency of the signal being produced; **2**

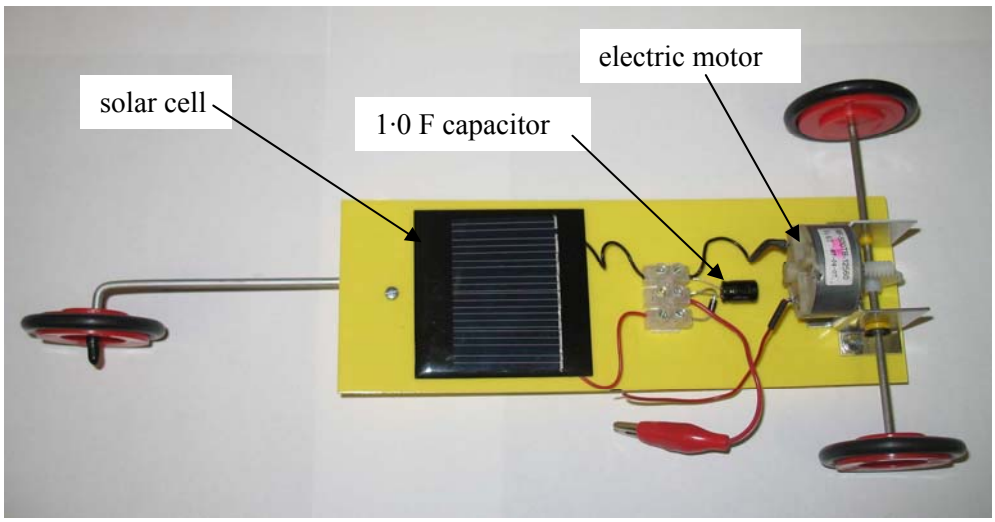
(ii) the r.m.s. voltage at the output of the wind turbine at this speed. **2**

(*b*) The wind speed is now increased. Describe the changes observed on the oscilloscope trace. **1**

(5)

Marks

27. A solar powered buggy uses a solar cell to charge a 1·0 F capacitor. The capacitor is then discharged through an electric motor to move the buggy.



The buggy is placed in bright sunshine for a time of 5 minutes. The output voltage of the solar cell is 2·0 V and the capacitor is fully charged in this time.

(*a*) Calculate the charge stored in the capacitor when it is fully charged. **2**

(*b*) Calculate the energy stored in the capacitor when it is fully charged. **2**

(*c*) The capacitor is then discharged through the electric motor. The buggy moves a distance of 2·4 m at constant speed before coming to a stop.

Calculate the average force of friction acting against the buggy as it moves. **2**

(*d*) The buggy is placed in sunlight once more until the voltage across the capacitor is 1·0 V.

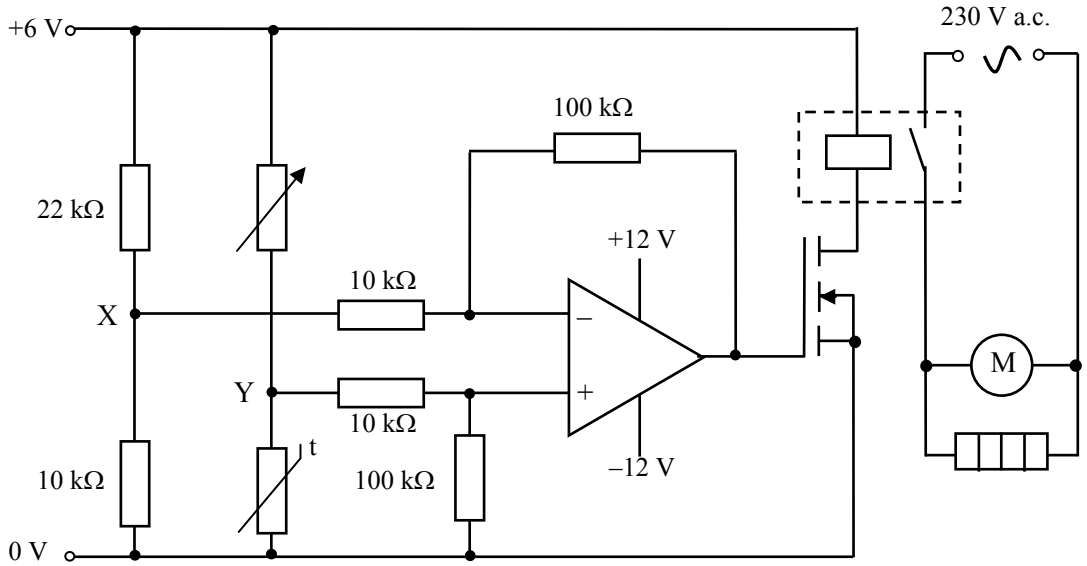
Assuming the average force of friction acting against the buggy remains constant, state the distance the buggy now moves. You must justify your answer. **2**

(8)

[Turn over

Marks

28. The circuit diagram of an automated electronic heating system is shown below.



(*a*) (i) In which mode is the operational amplifier in the diagram operating? **1**

(ii) Calculate the voltage gain of the operational amplifier circuit. **2**

(*b*) The resistance of the thermistor at various temperatures is given in the table below.

Temperature/°C	0	5	10	15	20	25	30
Resistance/kΩ	4·00	2·70	1·30	0·60	0·30	0·15	0·08

(i) The temperature of the thermistor is 15°C. The variable resistor is adjusted until there is no potential difference between points X and Y.

Calculate the resistance of the variable resistor. **2**

(ii) The variable resistor is now set to 800 Ω and the temperature is 10°C. Is the heater switched on or off? You must justify your answer by calculation. **4**

(*c*) Explain why the heater is not connected directly to the output of the MOSFET. **2**

(11)

[*END OF QUESTION PAPER*]

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Total Mark

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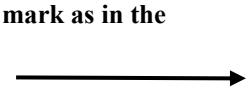
ANSWER SHEET (SECTION A)

First name and initials

Surname

Indicate your choice of answer with a single mark as in the following example.
USE HB PENCIL ONLY. ERASE ALL ERRORS THOROUGHLY.



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