National Qualifications 2007 – 2008

PHYSICS HIGHER

PRELIM EXAMINATION

Testing Units

D383 12 Mechanics and Properties of Matter
D380 12 Electricity and Electronics

Time: 2 hours 30 minutes

Read Carefully

1. All questions should be attempted.

Section A (questions 1–20)

2. Answer questions 1 to 20 on the answer sheet provided.
3. Fill in the details required on the answer sheet.
4. Rough working, if required, should be done on the paper provided – **not** on the answer sheet and **not** on the question paper.
5. For each of the questions 1 to 20 there is only **one** correct answer and each is worth 1 mark.
6. Instructions as to how to record your answers to questions 1 to 20 are before the questions.

Section B (questions 21 to 28)

7. Answer questions 20 to 28 on the paper provided. Each sheet must be named.
8. Enter the question number clearly in the margin beside each of your answers.
9. Care should be taken to give an appropriate number of significant figures in the final answer to calculations.
10. A copy of the Physics Data Booklet is provided for use with this examination.

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 an 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	9·8 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.

Instructions for Completion of Objective Test Answer Sheet

Physics Higher

Read carefully

Section A (questions 1 to 20)

1. All questions should be attempted.
2. **Print** your name and class in the boxes provided on the answer sheet.
3. Use **an HB pencil** for your answers. **Do not use ink.**
4. There is **only one correct** answer to each question.
5. Any rough working should be done on the paper provided, **not** on your answer sheet or question paper.
6. At the end of the exam, check that you have attempted every question, then place your answer sheet for Section A inside the **front** cover of this answer booklet.

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 your 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 kilowatt-hour

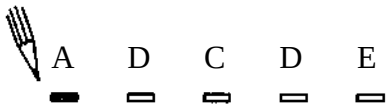
B ampere

C watt

D coulomb

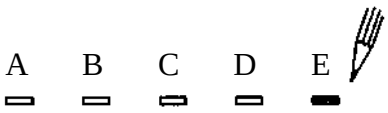
E volt.

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



Changing an answer

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



Section A

Answer questions 1 – 20 on the answer sheet.

1. Read these statements made by pupils.

I Distance and time are scalar quantities, velocity is a vector.

II Acceleration, weight and kinetic energy are all vector quantities.

III Force and momentum are vector quantities, but acceleration is a scalar.

Which of them is/are correct?

A I only

B II only

C III only

D I and II only

E I and III only

2. Tim throws a stone vertically down a well at 10 ms^{-1}. Matthew times its journey, hearing a splash after 3 seconds.

Ignoring air resistance and using $g = 10ms^{-2}$, the depth of the well is about

A 30 m

B 40 m

C 45 m

D 55 m

E 75 m

3. Which of these formulae could be used to calculate the speed of an object?

A F / P

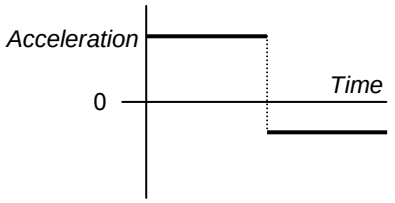
B $\sqrt{(½\ gh)}$

C $\sqrt{(2E_K / m)}$

D $\sqrt{(E_K / 2m)}$

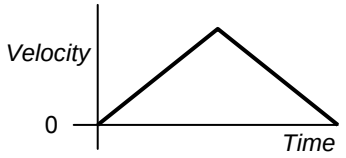
E $\sqrt{(2mgh)}$

4. Look at this acceleration / time graph.

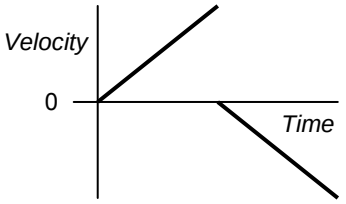


Which of these velocity / time graphs could represent the same motion (without a change in direction)?

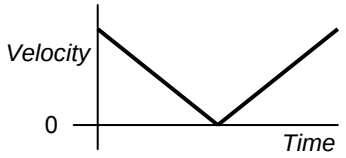
A



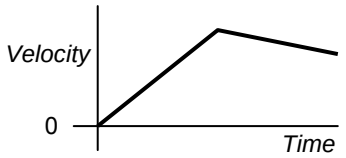
B



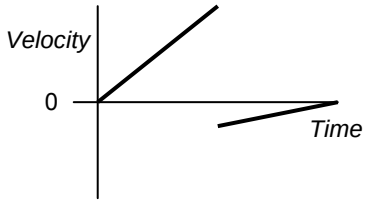
C



D



E



5. A 5000 kg tractor pulls an 8000 kg trailer full of bales. It accelerates along a straight, horizontal road at 1.5 ms^{-2}.

Ignoring frictional effects, the tension in the towing hitch is

A 4500 N

B 6500 N

C 7000 N

D 12000 N

E 19500 N

6. A radio-controlled plane of mass 50 kg is flying horizontally at 120 ms^{-1} when it is blown apart into two pieces for a film. Immediately after the explosion, a 20 kg piece continues horizontally in the original direction at 180 ms^{-1}. The other piece also continues horizontally in the original direction. Its speed is

A 0 ms^{-1}

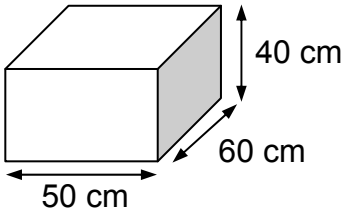
B 40 ms^{-1}

C 60 ms^{-1}

D 80 ms^{-1}

E 120 ms^{-1}

7. This block has a mass of 50 kg.



The maximum pressure it could exert on a surface on the Earth is about

A 4200 Pa

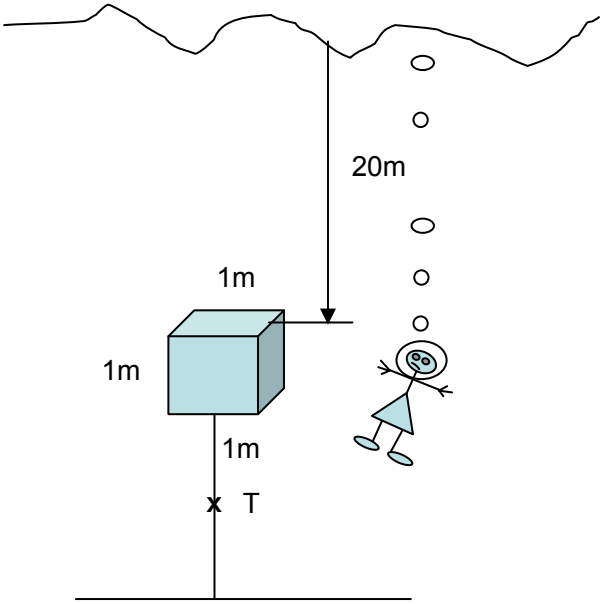
B 2500 Pa

C 2100 Pa

D 250 Pa

E 210 Pa

8. A pupil observes a cube of mass 10kg is suspended under water by a cable. The density of water is 1000 kg/m^3 Calculate the tension on the cable



A 9702N

B 8820N

C 1000N

D 600N

E 2468N

9. Iron enters a furnace at 300 K and is heated to a molten state at a temperature of 1900 K.

The temperature change on the Celsius scale is

A 1327 °C

B 1600 °C

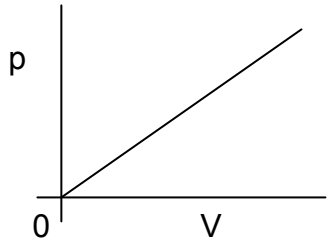
C 1873 °C

D 1927°C

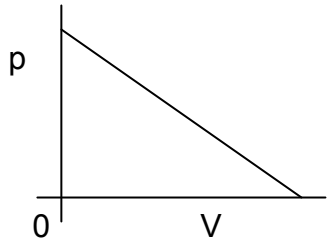
E 2200 °C

10. Which of these graphs shows correctly the relationship between the pressure (p) and volume (V) of a fixed mass of gas at constant temperature?

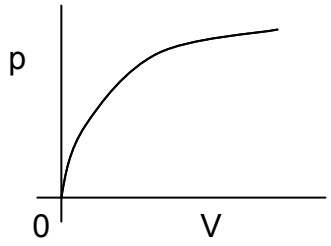
A



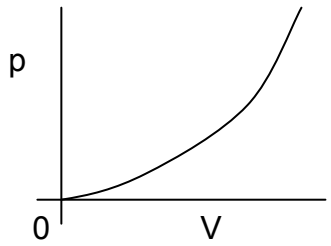
B



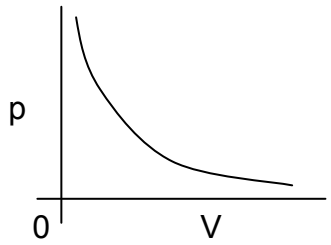
C



D

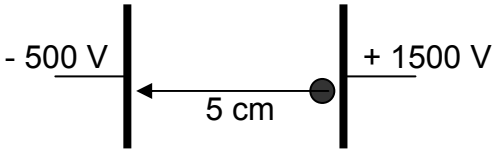


E



11. An α-particle has a charge magnitude equivalent to 2 electrons.

It moves 5 cm between two metal plates as shown.



The work done by the electric field on the α-particle is

A 1.28×10^{-14} J

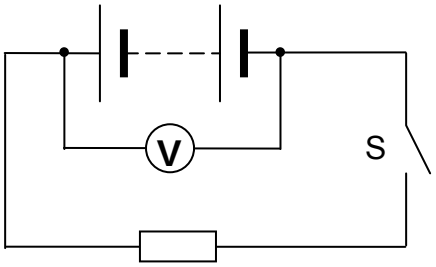
B 6.4×10^{-16} J

C 4.8×10^{-16} J

D 3.2×10^{-16} J

E 1.28×10^{-16} J

12. Examine this circuit.



When switch S is closed, the meter reads 3.6 V. When the switch is opened, the meter reads 4 V.

The emf of the supply is

A 0.4 V

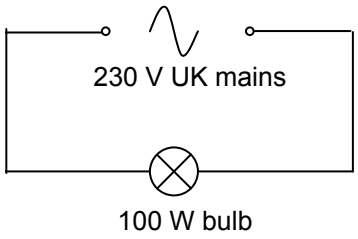
B 3.6 V

C 4.0 V

D 7.6 V

E 14.4 V

13. Look at this circuit.

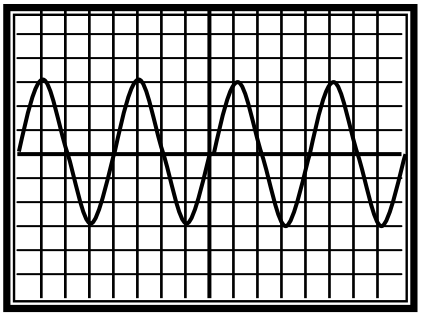


	Peak current (mA)	*Peak voltage (v)*
A	435√2	230√2
B	435	230
C	435 / √2	239 / √2
D	2300	230√2
E	2300√2	230√2

Which row in this table shows correctly the peak current through and the peak voltage across the 100 W bulb?

14. An oscilloscope is being used to measure the frequency of a signal.

The time-base is set on 5 ms per "div".
A screen shot is shown below.



The frequency of the signal is

A 10 Hz

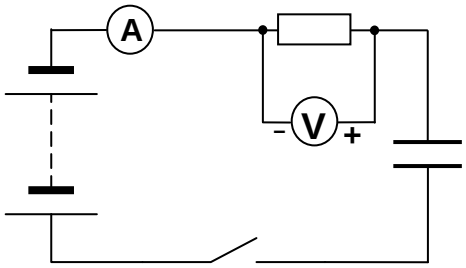
B 20 Hz

C 50 Hz

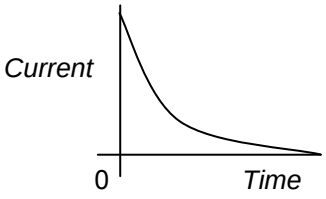
D 100 Hz

E 200 Hz

15. This circuit shows a charging circuit for a capacitor.

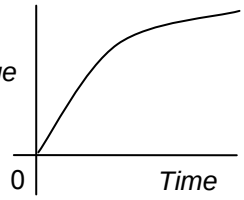


When the switch is closed, the current is monitored.
The current varies with time as shown in this graph.

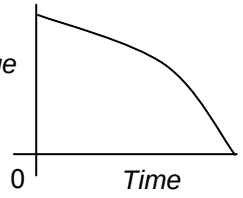


Which of these graphs shows correctly how the voltage across the **resistor** varies with time as the capacitor charges?

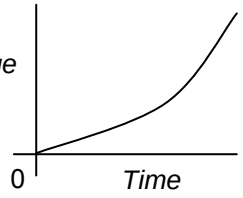
A



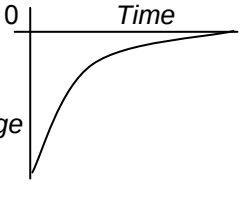
B



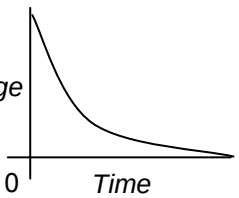
C



D



E



16. A coulomb meter is used to investigate the charge stored in a capacitor at different voltages.

At 1.5 V, the capacitor stores a charge of 3 mC.

At 9 V the capacitor stores a charge of

A 4·5 mC

B 13·5 mC

C 18 mC

D 27 mC

E 40·5 mC

17. The unit for capacitance is the farad (F).

1 F is the same as

A $1\ VC^{-1}$

B $1\ C^2J^{-1}$

C $1\ V^2J^{-1}$

D 1 CV

E $1\ JV^2$

18. Three pupils are arguing about op-amps.

Martin says: "Op-amps can reduce or increase the voltage of an a.c. signal."

Travis says: "No. Op-amps are amplifiers – so they can only make voltages bigger!"

Nyree says: "Well, I think op-amps can increase or reduce the voltage of *any* signal, a.c. or d.c."

Whose statement(s) is/are correct?

A Martin only

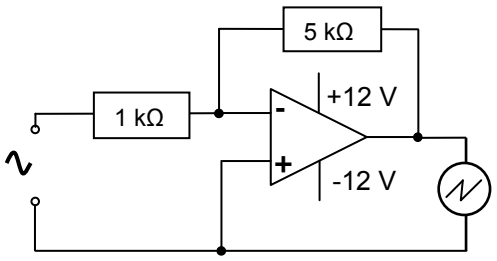
B Travis only

C Nyree only

D Martin and Nyree only

E None of them

19. The following circuit is used to monitor the output voltage and frequency of an op-amp.



For an a.c. input of ±3 V peak at a frequency of 1 kHz, which line in this table is correct?

	Peak Output Voltage (±V)	*Output Frequency* (kHz)
A	0. 6	0.2
B	12	1
C	15	5
D	12	5
E	Less than 12	1

20. In an experiment, three measured quantities X, Y, and Z must be combined, using the formula

$$P = (Z - X) / Y$$

to give the required result.

The data to be used is

$$X = 50 \pm 1$$

$$Y = 6.0 \pm 0.2$$

$$Z = 80 \pm 1$$

The answer and the best estimate of the uncertainty is

A 5.0 ± 0.17

B 5.0 ± 0.10

C 5.0 ± 0.18

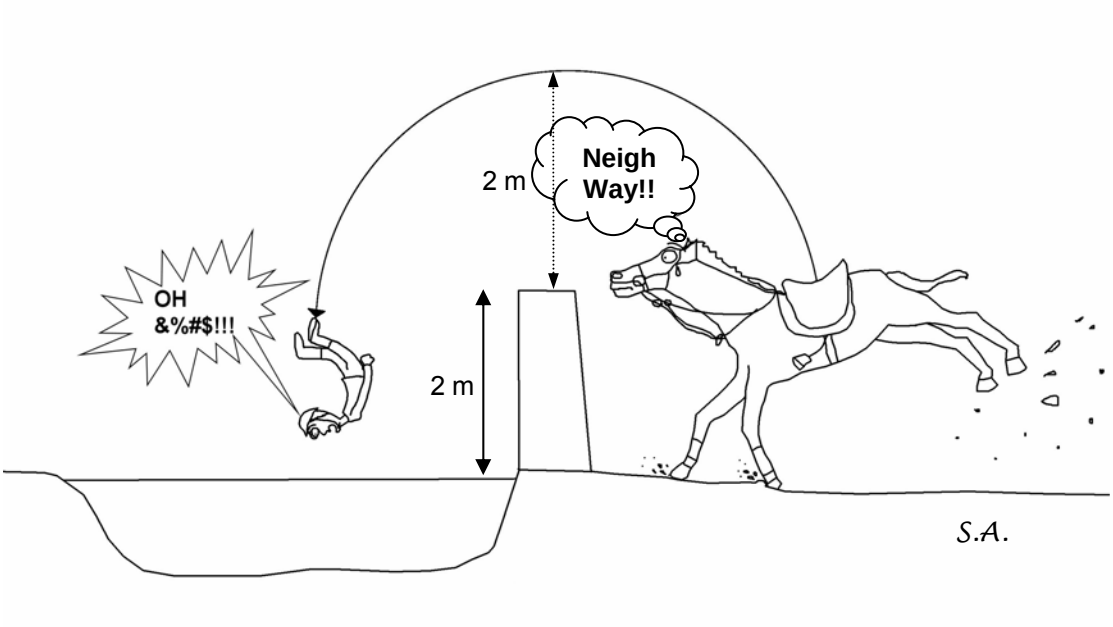
D 5.0 ± 0.06

E 5.0 ± 0.04

Section B

Write your answers to questions 21 to 27 on the lined paper provided.

21. Jim is competing in a cross-country event when his horse throws him at the water jump.



The horse is moving at 12 ms^{-1} horizontally when it throws him.
Annie is watching closely and estimates that Jim clears the top of the 2.0 metre high fence by 2.0 metres at the top of his "flight".

(a) Calculate Jim's vertical velocity on hitting the water. 2

(b) Jim is at a level of 1.7 m vertically above the water surface when he is unseated.

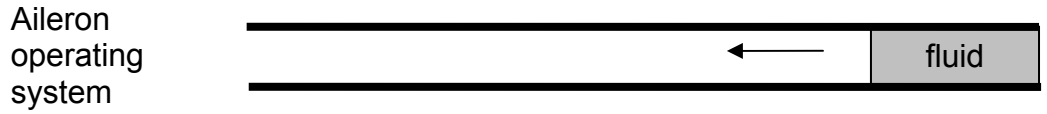
(i) Show by calculation, that Jim is "flying" through the air for a total of 1.6 s. 4

(ii) How far did Jim "fly" horizontally? 2

(c) Find the magnitude and direction of Jim's initial velocity on being unseated. 3

(11)

22. A pilot is concerned with the operating systems within her aircraft.
Hydraulic fluid within a pipe is used to operate the ailerons to control the altitude. A diagram of the system is shown below



The length of the pipe from the control system to the ailerons is 70 m.

The fluid attains a speed of 58 ms^{-1} just before it leaves the pipe. The fluid starts from rest.

(a) **(i)** Calculate the average acceleration of the fluid in the pipe. 2

(ii) The design parameters assume a cylindrical "plug" of fluid, of mass 2 kg, and an average frictional force within the pipe of 2 N. Show that the magnitude of the force moving the fluid through the pipe is 50N.

2

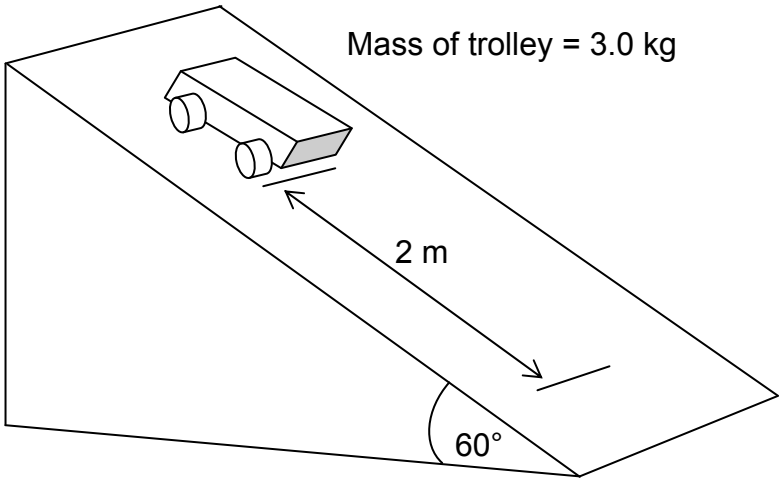
(iii) How long does it take for the fluid to pass through the pipe? 2

(b) As the fluid reaches the end of the pipe it increases in temperature due to friction. The temperature change is found to be from 22°C to 26°C. When the fluid is at the start of the pipe it is at a pressure of 50Pa. Calculate the pressure of the fluid at the end of the pipe (assuming constant volume).

2

(8)

23.



The diagram is not drawn to scale.

A pupil set up the apparatus shown above and allowed the 3.0 kg truck to roll down the slope.

(a) Show that the component of weight acting down the slope is 25.5 N.

2

(b) Once released, the truck travels down the slope.

Calculate the maximum energy that the truck could gain for the 2 metre section shown.

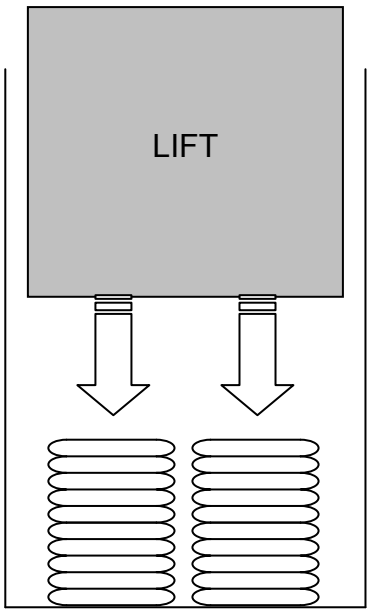
2

(c) If the force of friction against the trolley down the slope is 2N calculate the acceleration of the trolley.

2

(6)

24. Researchers are experimenting with methods of reducing the catastrophic effects of a lift falling out of control. They install what look like large corrugated metal oil drums at the bottom of a lift shaft and allow the lift to fall 20 metres onto them. They crumple in a controlled way, as they stop the falling lift.



(a) The fully loaded lift has a mass of 750 kg. When it hits the crumpling drums, they bring the lift to a halt in 0.7 seconds.

(i) Use conservation of energy to calculate the speed at which the lift hits the drums. 2

(ii) What is the magnitude of the change of momentum as the lift as it stops? 2

(iii) Find the magnitude of the average force the drums exert on the lift. 2

(b) Using only **one** set of axes, sketch two labelled graphs showing how the stopping force varies with time.

(**One** numerical value must be shown on the **time** axis.)

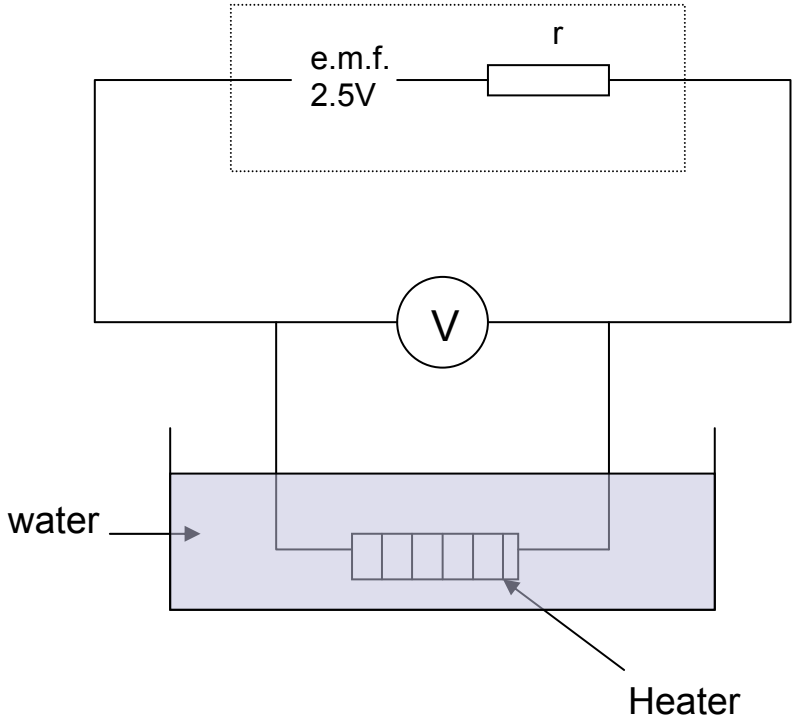
(i) For the lift stopping with no crumpling drums. 1

(ii) When the drums are used to break the lift's fall. 1

(c) What size is the impulse on the lift when it hits with no drums to break its fall, if it again drops 20 m? 1

(9)

25. A heater of resistance 0.5 ohms is connected to a power supply of e.m.f. 2.5 volts and internal resistance r as shown below.



(a) The power output of the heater is 8.0 Watts

Calculate:

(i) the current in the heater 2

(ii) the reading on the voltmeter 1

(iii) the internal resistance of the power supply 2

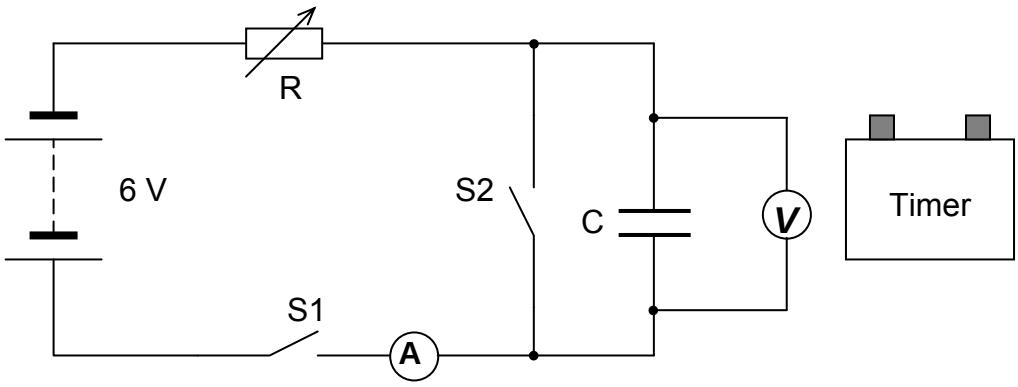
(b) Another identical heater is now placed in the water and connected in parallel with the original heater. The rest of the circuit is unaltered.

(i) How does this affect the temperature of the water. 1

(ii) Calculate the total current flowing through the two heaters 2

(8)

26. Duncan, Tim and Matthew are investigating how charge and voltage are related for a capacitor. They set up this circuit.



They close S1 and while one watches the ammeter and adjusts R to keep the current constant, the other two note the reading on the voltmeter every 10 seconds. This is repeated a few times to get accurate values for V.

(a) What is the purpose of S2? 1

(b) Describe how the resistance of R must be changed to maintain a constant current during charging. 1

(c) The ammeter reads a constant current of 500 μA.

What charge has passed to the capacitor after 30 seconds? 2

(d) Sketch a graph to show how you would expect the charge stored in the capacitor to vary with the voltage across it. 1

(e) What is represented by the area under this graph? 1

(f) The boys are using a 5000 μF capacitor.

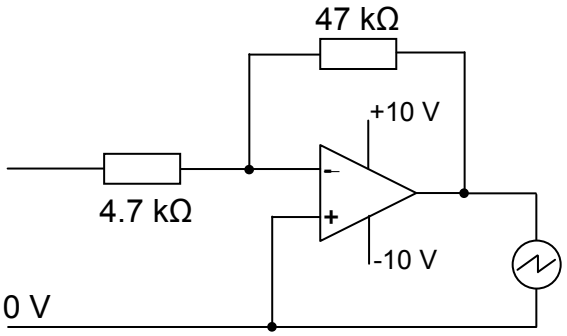
How much charge does it store when it is fully charged using the circuit shown? 2

(g) The capacitor casing states "V_{max} = 12 V".

How much energy could the capacitor store at V_{max}? 2

(10)

27. Duncan set up this op-amp circuit.



(a) In which mode is this op-amp working? 1

(b) **(i)** Calculate the gain of the op-amp. 1

(ii) Calculate the output of the op-amp when +500 mV is connected to the input. 2

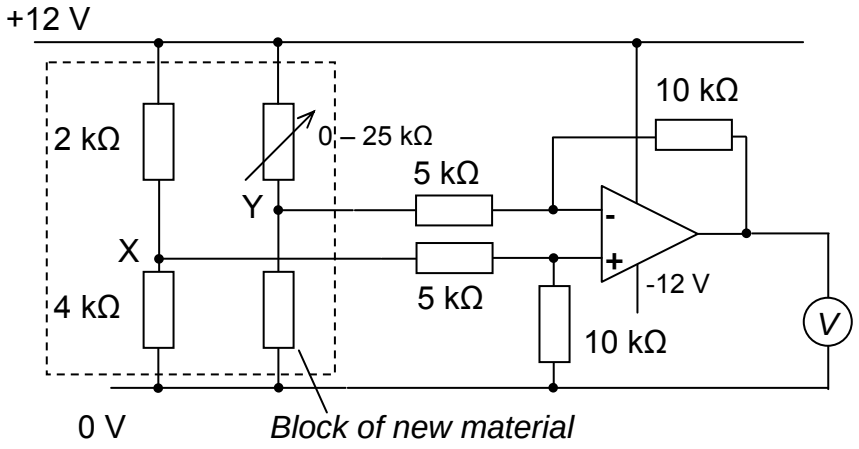
(c) Duncan now connects an a.c. supply of 2.15 V r.m.s. across the input. He connects the oscilloscope across the input.

(i) Draw a sketch of the input voltage. (you must indicate the maximum voltage). 2

(ii) Draw a sketch of the output voltage. (you must indicate the maximum voltage). 2

(8)

28. An electronics engineer is testing a new elastic material whose resistance decreases as it is squashed and increases as it is stretched.
He uses this circuit.



(a) When the variable resistor is set at 10 kΩ, the output of the op-amp is zero volts.

Calculate the resistance of the block of new material. 2

(b) A force is now exerted on the new material, causing the output of the op-amp to change to –2 V.

(i) Calculate the potential difference across XY. 2

(ii) Calculate the potential at Y. 2

(iii) State whether the new material was stretched or squashed, and **explain** your answer. 3

(c) The block of new material was then incorporated in an electronic dynamometer (a force meter that can measure a push or a pull) with a digital display.

What would the variable resistor be used for? 1

(10)

END OF QUESTION PAPER