Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S 3 0 0 4	INDEX NUMBER	

PHYSICS **9749/02**

Paper 2 Structured Questions

26 August 2021
2 hours

Candidates answer on the Question Paper.
No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your Name, Class and Index number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiners' use only	
1	/ 7
2	/ 11
3	/ 10
4	/ 9
5	/ 11
6	/ 12
7	/ 20
Total	/ 80

DATA AND FORMULAE

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

For Examiner's Use

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\,\Delta V$
hydrostatic pressure,	p	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	$T/°C + 273.15$
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current	I	=	$A n v q$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

Answer **all** the questions in the spaces provided.

1 The speed v of a transverse wave on a uniform string is given by the expression

$$v = \sqrt{\frac{Tl}{m}}$$

where T is the tension of the string, l is its length and m is its mass.

An experiment is conducted to determine the speed v of the wave. The measurements are shown in Table 1.1.

Table 1.1

quantity	measurement	uncertainty
T	1.8 N	0.1 N
l	126 cm	2 cm
m	5.1 g	0.2 g

(a) **(i)** Using the data in Table 1.1, determine the percentage uncertainty in the calculation of the speed v of the transverse wave.

percentage uncertainty = ... % [2]

(ii) Using your answer in **(a)(i)** and the data in Table 1.1, determine the value of v, with its absolute uncertainty, to an appropriate number of significant figures.

v = ... ± .... m s^{-1} [2]

For Examiner's Use

(b) Another student used a different set-up to determine the value of v. His values of v are as follows:

$$20.6 \text{ m s}^{-1}, 21.1 \text{ m s}^{-1}, 20.4 \text{ m s}^{-1}$$

(i) With reference to the value of v obtained in **(a)(ii)**, comment on the accuracy of the values of v that the second student obtained.

....

.... [1]

(ii) State the type of error that is present in the measurements obtained by the second student.

Suggest a possible way to minimise or eliminate the error.

....

....

.... [2]

For Examiner's Use

2 A ball is kicked from horizontal ground towards a vertical wall as shown in Fig. 2.1.

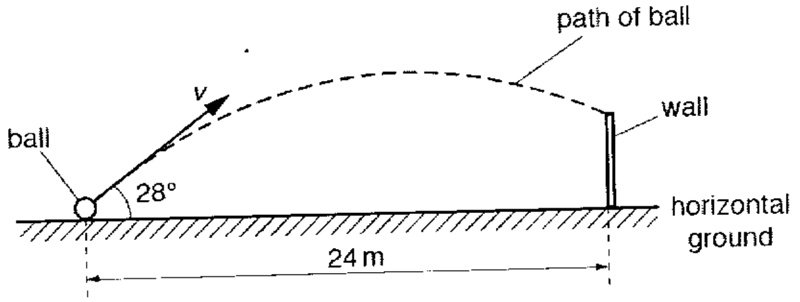


Fig 2.1 (not to scale)

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball just hits the top of the wall after a time of 1.5 s.

(a) Calculate the horizontal component v_X of the velocity of the ball.

v_X = ... m s^{-1} [1]

(b) Hence or otherwise, show that the initial vertical component v_Y of the velocity of the ball is 8.5 m s^{-1}.

[1]

For Examiner's Use

(c) The ball is kicked at time $t = 0$. Assume that the vertical component v_Y of the velocity of the ball is positive in the upwards direction.

(i) On Fig. 2.2, sketch the variation with time t of v_Y for the time until the ball hits the wall.

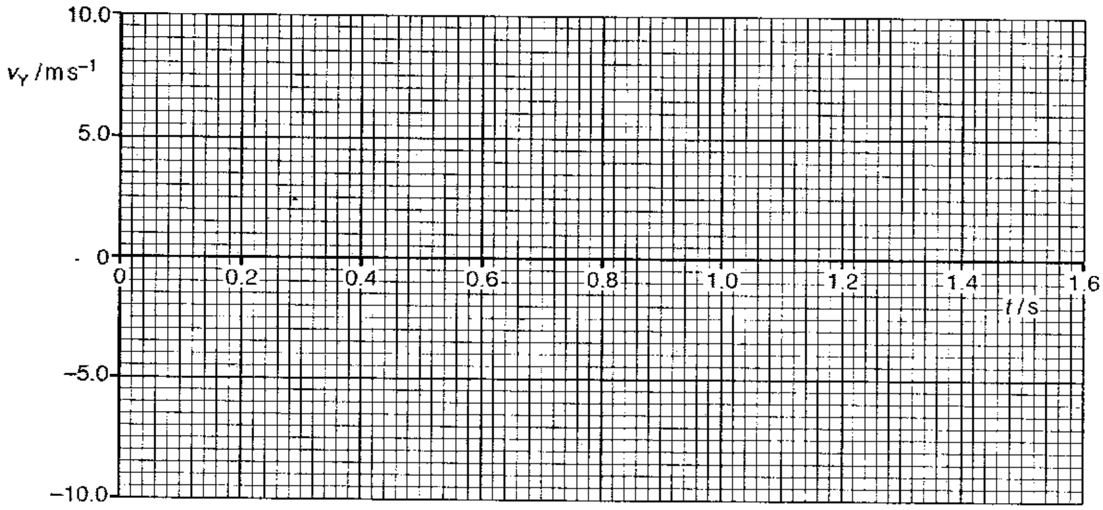


Fig. 2.2

[3]

(ii) Using Fig. 2.2, determine the maximum height above the ground that the ball reached.

maximum height = ... m [2]

(iii) Hence or otherwise, determine the ratio of its $\frac{\text{kinetic energy}}{\text{gravitational potential energy}}$ when the ball is at its maximum height.

ratio = ... [2]

(iv) If air resistance is not negligible, on Fig 2.2, sketch the variation with time t of v_Y for the time until the ball hits the ground.

Label this line W.

[2]

[Turn over

For Examiner's Use

3 **(a)** Define *upthrust*.

....

....

.... [2]

(b) A mass M with a wire attached to it is fully submerged in water as shown in Fig. 3.1. Mass M is 950 kg with a base area of 0.40 m^2 and a height of 0.50 m.

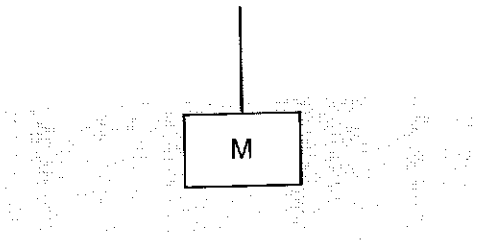


Fig. 3.1

Given that the density of water is 1000 kg m^{-3}, show that the tension in the wire is 7360 N.

[2]

For Examiner's Use

(c) Mass M is actually being held up by a crane made of a uniform rigid beam AB hinged to the ground at A, and held in place by two wires CD and BE, as shown in Fig. 3.2.

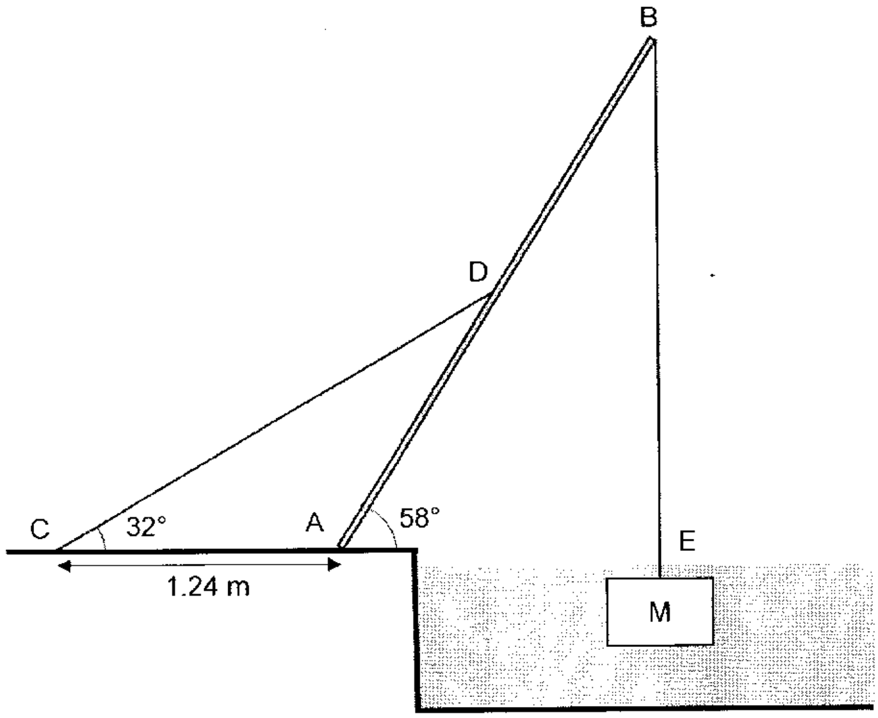


Fig. 3.2

The beam AB has a length of 3.00 m and a mass of 80.0 kg.

D is the midpoint of rod AB.

(i) Calculate the tension in the wire CD, T_{CD}.

T_{CD} = ... N [2]

For Examiner's Use

(ii) Explain why the hinge must exert a force on the beam at A to keep the beam in equilibrium.

....

....

....

.... [2]

(iii) With suitable calculations or otherwise, explain whether the direction of the force the hinge exerts on the beam at A is above AB (angle to the horizontal > 58°), along AB (angle to the horizontal = 58°), or below AB (angle to the horizontal < 58°).

....

....

.... [2]

For Examiner's Use

4 A battery of electromotive force (e.m.f.) 3.0 V and negligible internal resistance is connected to a potentiometer, as shown in Fig. 4.1.

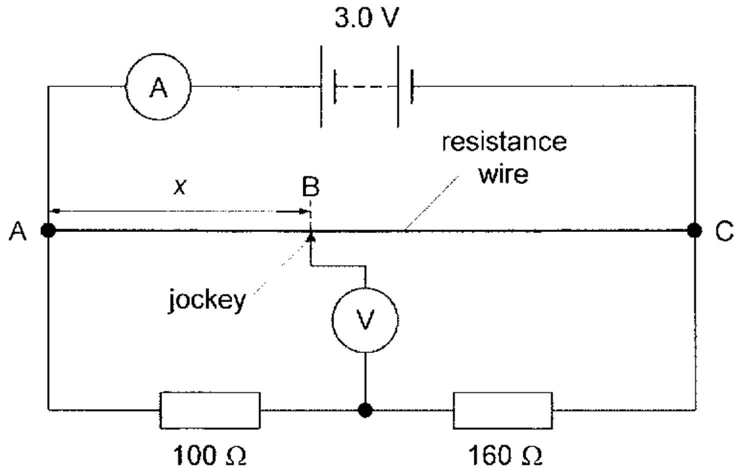


Fig. 4.1

The potentiometer consists of a 90 cm length of resistance wire AC. It is connected in parallel with a 100 Ω resistor and a 160 Ω resistor.

The jockey is in contact with the resistance wire at position B and the distance between A and B is x.

(a) **(i)** The jockey is adjusted until the voltmeter reading is zero.

Determine the value of x.

x = ... cm [2]

(ii) The ammeter reading is 234 mA.

Show that the resistance of wire AC is 13.5 Ω.

[2]

[Turn over

For Examiner's Use

(iii) State and explain the change, if any, to the resistance determined in **(a)(ii)** if the battery has internal resistance.

....

....

....

....

.... [2]

(b) An ideal diode is connected to the circuit and the battery is replaced by a 50 Hz sinusoidal alternating current (a.c.) power supply of peak voltage 12 V, as shown in Fig. 4.2.

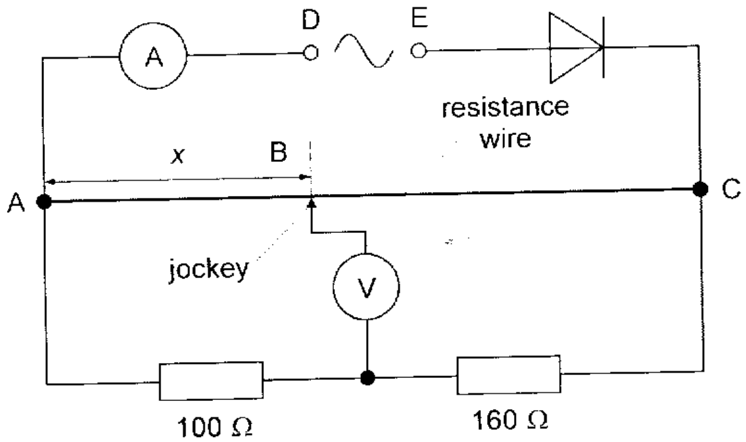


Fig. 4.2

(i) Determine the mean power dissipated in the resistance wire AC.

mean power = ... W [2]

(ii) Junctions D and E are connected to a cathode-ray oscilloscope (c.r.o.). The vertical scale of the c.r.o. is set to 4 V per division and the time-base is set to 5 ms per division.

Sketch the trace on the screen of the c.r.o. in Fig. 4.3.

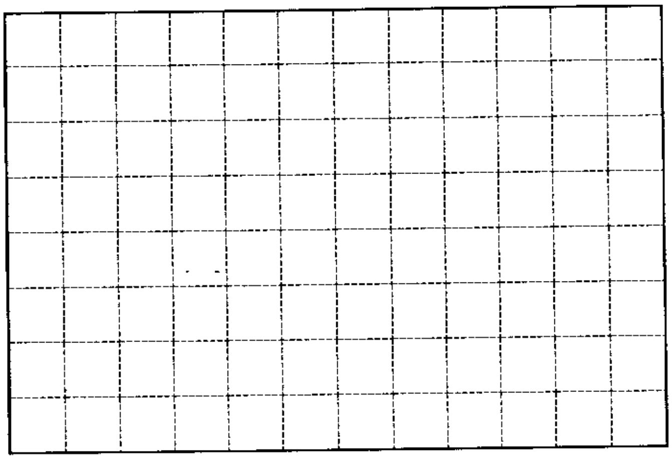


Fig. 4.3

[1]

For Examiner's Use

5 **(a)** Wire A is a long current-carrying low resistance wire that passes through and is normal to the horizontal plane as shown in Fig. 5.1. d is the horizontal distance away from wire A.

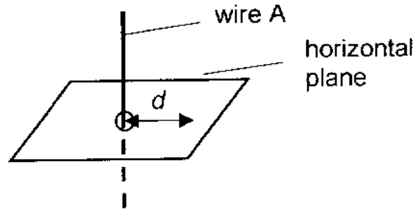


Fig. 5.1

The magnetic field due to the Earth and wire A are B_E and B_W respectively. A miniaturized compass is placed at d = 0.8 cm due East of wire A as shown in Fig. 5.2. At this position, B_W is slightly larger than B_E.

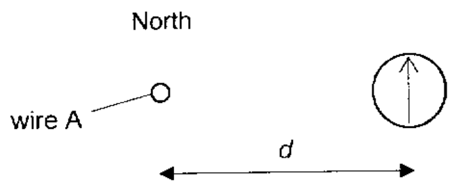


Fig. 5.2

(i) When the current in the wire A is switched off, there is no change in the angle of deflection of the compass.

State the direction of the current in the wire A as shown in Fig. 5.2.

....[1]

For Examiner's Use

(ii) The compass is replaced by a magnetic field sensor connected to a datalogger. By varying d, the resultant magnetic field B at that position is obtained.

Fig. 5.3 shows the variation of B against $\frac{1}{d}$.

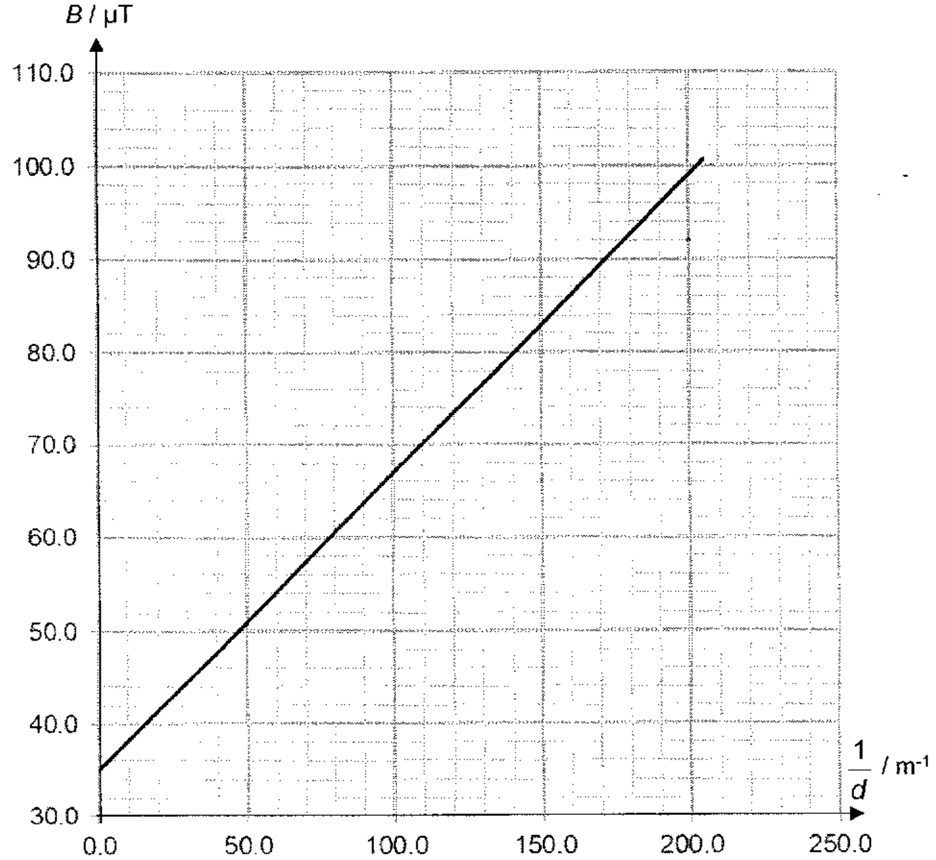


Fig. 5.3

1. B_E is the value of the y-intercept in Fig. 5.3. State the magnitude of B_E.

B_E = ... μT [1]

2. Explain why the y-intercept is the magnitude of B_E.

....

....

.... [1]

For Examiner's Use

3. Using your answer in **(a)(ii)1.** and Fig. 5.3, determine the current in the wire A, I_W.

I_W = ... A [3]

(iii) Another current carrying wire, wire B, is placed parallel to wire A and at d = 0.8 cm due South of it as shown in Fig. 5.4. The direction of current in wire B points into the page.

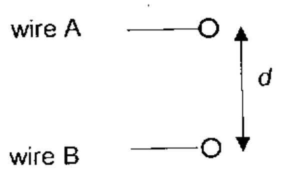


Fig. 5.4

On Fig. 5.4, draw the resultant magnetic force that acts on wire A and the resultant magnetic force that acts on wire B. Label the forces F_A and F_B respectively.

[1]

For Examiner's Use

(b) A copper disc spins freely between the poles of an unconnected electromagnet as shown in Fig. 5.5.

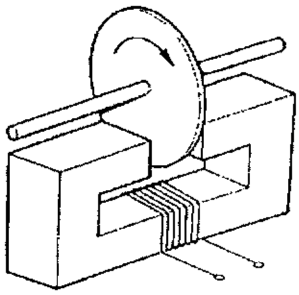


Fig. 5.5

Describe and explain what will happen to the speed of rotation of the disc when a direct current is switched on in the electromagnet.

....

....

....

....

....

....

....

....

.... [4]

For Examiner's Use

6 (a) Two observations about the photoelectric effect are:

Observation 1: For light below the threshold frequency, no electrons are emitted from the metal surface.

Observation 2: For light above the threshold frequency, the emission of electrons is almost instantaneous.

For each of the observation, explain how it provides support for the particle theory of light, but not the wave theory of light.

(i) Observation 1 : ....

....

....

.... [2]

(ii) Observation 2 : ....

....

....

.... [2]

(b) A narrow parallel beam of laser light is incident on a barium surface at an angle of incidence of 30°, as shown in Fig. 6.1.

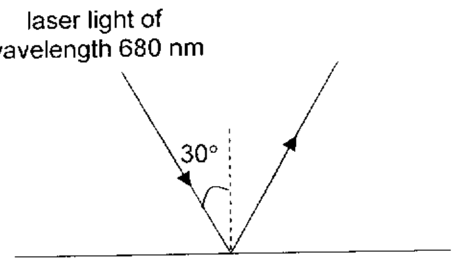


Fig. 6.1

The beam has a circular cross-section of diameter 1.5 mm.

The laser light has wavelength of 680 nm and intensity 3.2×10^{3} W m^{-2}.

For Examiner's Use

(i) Determine

1. the energy of a photon of the laser light; and

energy = ... J [2]

2. the number of photons incident per unit time on the surface.

number of photons per unit time = ... s^{-1} [2]

(ii) Assuming that all the photons are reflected, calculate the force F normal to the surface that is exerted by the laser light on the surface.

force = ... N [3]

(iii) Due to the property of metal, a percentage of the photons incident on the surface is absorbed. Explain how this would affect your answer in **(b)(ii)**.

....

....

.... [1]

For Examiner's Use

7 The capacitor is an electrical component which has the ability or "capacity" to store energy in the form of an electrical charge, producing a potential difference across its plates, much like a small rechargeable battery.

When an electric potential is applied across the terminals of a capacitor, for example when a capacitor is connected across a battery, electrons will move from one of the terminal to the other via the battery. No current flows between the two plates. The current through the source circuit will eventually cease when the electric potential across the capacitor reaches that of the battery. This process is known as charging.

When the capacitor is now attached to a circuit, it will behave like a battery due to the charges accumulated across its terminals. However, unlike a battery, the voltage and current that it produces decreased with time as the charges on its plates is limited. This process is known as discharging.

The ability of the capacitor to store charges is known as capacitance *C*, measured in Farads (F), which is the ratio of the amount of electric charge *Q* stored to the difference in electric potential *V* across it. *C* can therefore be expressed as

$$C = \frac{Q}{V}$$

The parallel plate capacitor is the simplest form of capacitor. It can be constructed using two metal foil plates of surface area *A*, separated at a distance *d* and placed parallel to each other. The two plates are electrically separated either by air or by some form of a good insulating material such as mica, ceramic or plastic as shown in Fig 7.1. This insulating layer is commonly called the dielectric. The dielectric constant ε measures the amount of electric potential energy that the dielectric can store under the influence of an electric field.

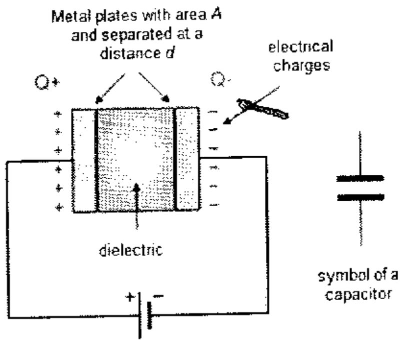


Fig 7.1

C can therefore also be expressed as

$$C = \varepsilon \frac{A}{d}$$

For Examiner's Use

(a) Data comparing the variation of capacitance *C* with the separation between the conducting plates of 4 capacitors is as shown in Fig. 7.2 and Fig 7.3.

	Capacitor			
	W	X	Y	Z
Separation *d* / mm	Capacitance *C* / nF			
0.10	0.103	0.053	0.089	0.124
0.20	0.052	0.027	0.044	0.062
0.30	0.034	0.018		0.041
0.40	0.026	0.013	0.022	0.031

Fig 7.2

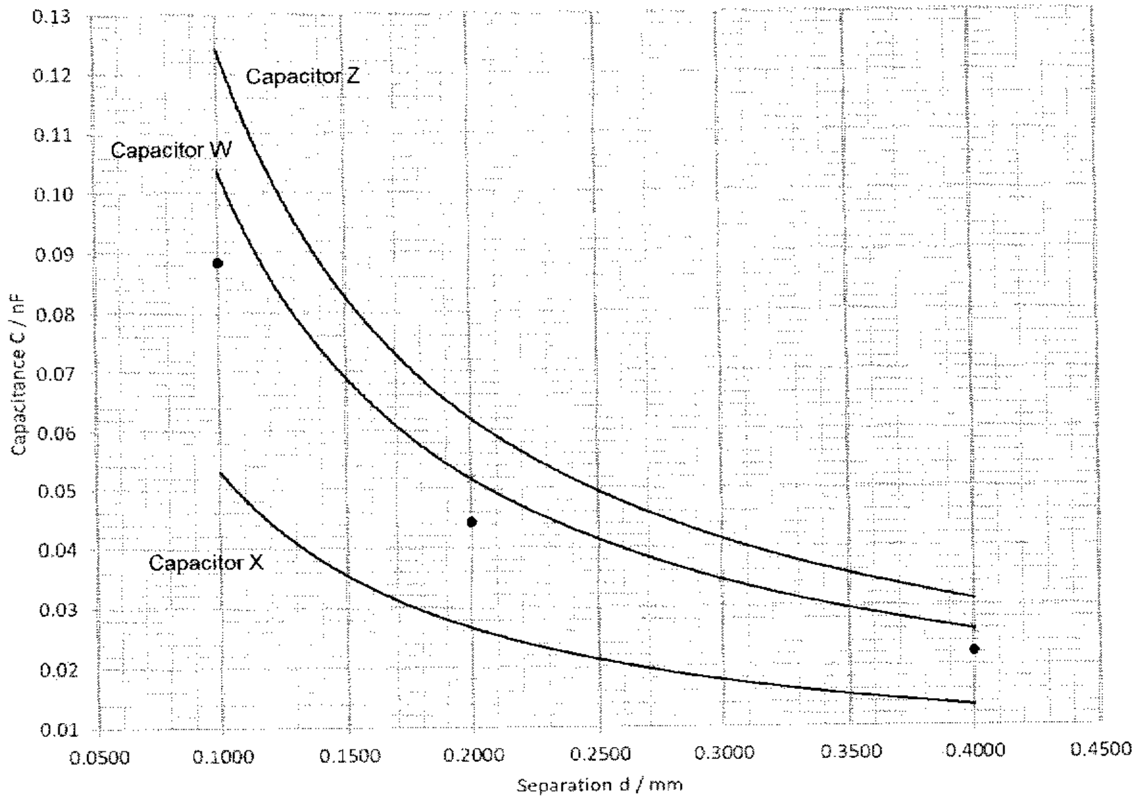


Fig 7.3

(i) Complete Fig 7.2 for Capacitor Y.

[1]

(ii) On Fig 7.3, plot the missing capacitance value for Capacitor Y. Complete Fig 7.3 by drawing the best fit line for Capacitor Y.

[2]

(iii) Using Fig 7.3, determine the value of *C* for capacitor Z when *d* = 0.15 mm

C = ... nF [1]

[Turn over

For Examiner's Use

(iv) Hence, given that the area A for Capacitor Z is 1.0×10^{-4} m^2, determine the values of its dielectric constant ε.

ε = ... F m^{-1} [2]

(b) Fig 7.4 shows a setup that can be used to charge a capacitor. An e.m.f source V_s is arranged in series with a resistor R and a capacitor C.

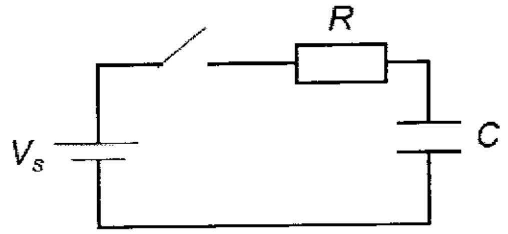


Fig 7.4

When the switch is closed, the voltage across the capacitor V_c can be expressed as

$$V_c = V_s(1 - e^{-t/RC})$$

where t is the time from which the switch is closed.

(i) Explain why after the switch is closed, the current through the resistor will eventually decrease to zero.

....

....

....

....

.... [2]

(ii) Hence or otherwise, deduce an expression for the variation with time of the current passing through the resistor I_R.

I_R = ... [1]

For Examiner's Use

(c) When the e.m.f. source is removed from Fig 7.4, the circuit can be used for to discharge a capacitor as shown in Fig 7.5.

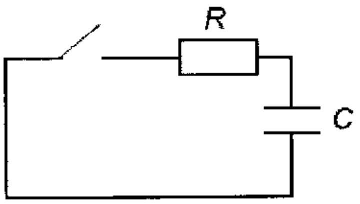


Fig 7.5

When the switch is closed, the voltage across the capacitor V_c can be expressed as

$$V_c = V_o e^{-t/RC}$$

where V_o is the initial voltage across the capacitor while t is the time from which the switch is closed.

(i) Suggest why the voltage across the capacitor decreases *exponentially* during discharge.

....

....

....

....

.... [2]

(ii) Despite not being able to maintain a constant voltage output, capacitors are widely used in almost all electronic devices.

State an advantage that the capacitor has over a battery.

....

....

.... [1]

For Examiner's Use

(d) A student uses the capacitor to model a signal generator, which sends a signal periodically when switched on. A model of the signal generator is as shown in Fig 7.6 where a 12.0 V battery is placed in series with a variable resistor and a 20.0 μF capacitor. A device is place across the output of the signal generator.

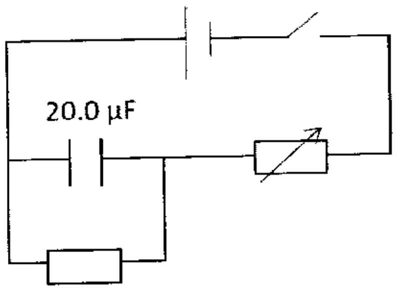


Fig 7.6

The device can be considered to have a very large resistance until the potential difference across it reaches 8.0 V. At 8.0 V, its resistance decreases to a negligible level and allows the capacitor to fully discharge through it almost instantly. The resistance of the variable resistor is initially set to be 5.0 Ω.

(i) Determine the maximum amount of charge that can be stored in the capacitor.

amount of charge = ... C [1]

(ii) When the switch is closed, determine the time taken for the capacitor to reach 8.0 V.

time = ... s [2]

(iii) Hence or otherwise, determine the frequency output of the signal generator.

frequency = ... Hz [1]

For Examiner's Use

(iv) Fig 7.7 shows the variation with time of the voltage across the capacitor as the resistance of the variable resistor is varied over four different values.

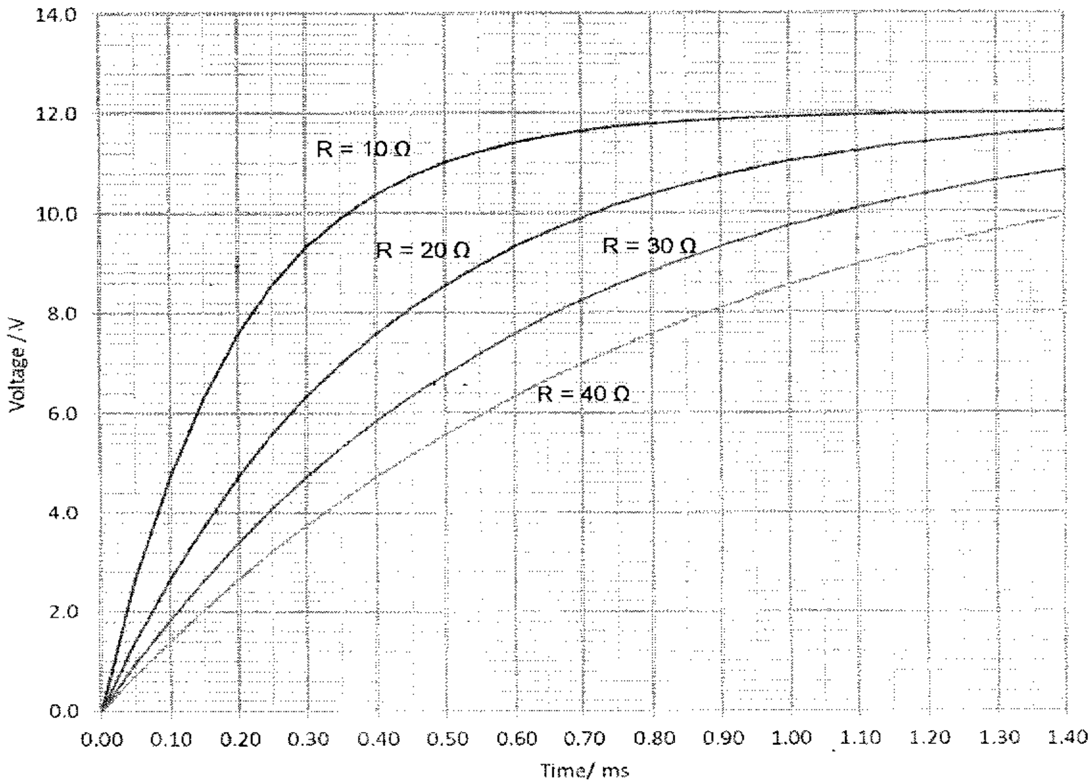


Fig 7.7

1. Using Fig 7.7, explain how the variable resistor can be used to increase the frequency of the signal generator.

....

....

....

.... [2]

2. If the signal generator is to have a frequency of at least 2 kHz, determine all possible resistance value(s) in Fig. 7.7 that can be used.

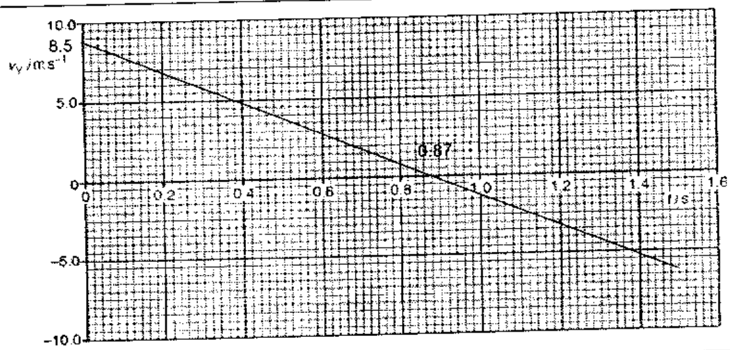
resistance = ... Ω [2]

End of Paper

[Turn over

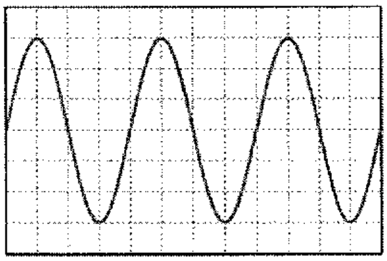
Annotations used in marking
BOD - Benefit of doubt
ECF - Error carried forward
POT - Powers of ten error
TE - Transfer error
CE - Calculation error
XP - Wrong physics
ENG - Generally bad english, phrasing and expression
PP - Poor presentation of answers
Note: For POT and TE, we can award the M mark, not the A mark.

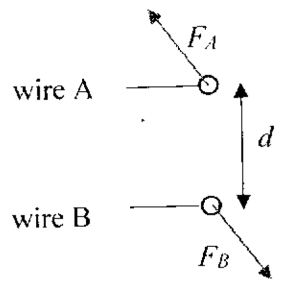
Qn	**Suggested MS**
1	
(a)(i)	$\frac{\Delta v}{v}=\frac{1}{2}\left(\frac{\Delta T}{T}\right)+\frac{1}{2}\left(\frac{\Delta l}{l}\right)+\frac{1}{2}\left(\frac{\Delta m}{m}\right)$ $=\frac{1}{2}\left[\frac{0.1}{1.8}+\frac{2}{126}+\frac{0.2}{5.1}\right]$
	$=0.055$ $=5.5\%$
	OR
	Find max and min value
	Take average and correct answer
(a)(ii)	$v=\sqrt{\frac{(1.8)(1.26)}{(5.1\times10^{-3})}}$ $=21.08805\text{ m s}^{-1}$
	$\frac{\Delta v}{v}=0.055$ $\Delta v=0.055(21.00805)$ $=1\text{ m s}^{-1}$ $v=(21\pm1)\text{ m s}^{-1}$
(b)(i)	Average value of 20.7 m s^{-1} falls within the range due to experimental error.
(b)(ii)	Random error
	Repeat the experiment more times so that the average value will tend towards the true value.

2	
(a)	$v_x = \frac{s_x}{t}$ $= \frac{24}{1.5}$
	$= 16 \text{ m s}^{-1}$
(b)	$\tan 28° = \frac{v_y}{v_x}$ $v_y = (16)\tan 28°$ $= 8.51$
	$= 8.5 \text{ m s}^{-1}$
(c)(i)	
	Straight line with negative gradient
	Gradient = 9.81 m s^{-2} →, t = 0.87 s → cut at 0.84 s < t < 0.90 s
	Stop at t = 1.5 s, magnitude of v_y must be less than initial
(c)(ii)	maximum height = area under the v-t graph
	$= \frac{1}{2}(0.866)(8.5)$ $= 3.7 \text{ m}$
(c)(iii)	$\frac{\text{k.e.}}{\text{g.p.e}} = \frac{(1/2)mv_x^2}{mgh}$ $= \frac{(1/2)(16)^2}{(9.81)(3.7)}$
	$\frac{\text{k.e.}}{\text{g.p.e}} = 3.5$
(iv)	Steeper initial gradient, which decreases over time. Area above and below must be the same.
	Tangent to curve where it cuts the time-axis is parallel to original graph and must be the correct shape.

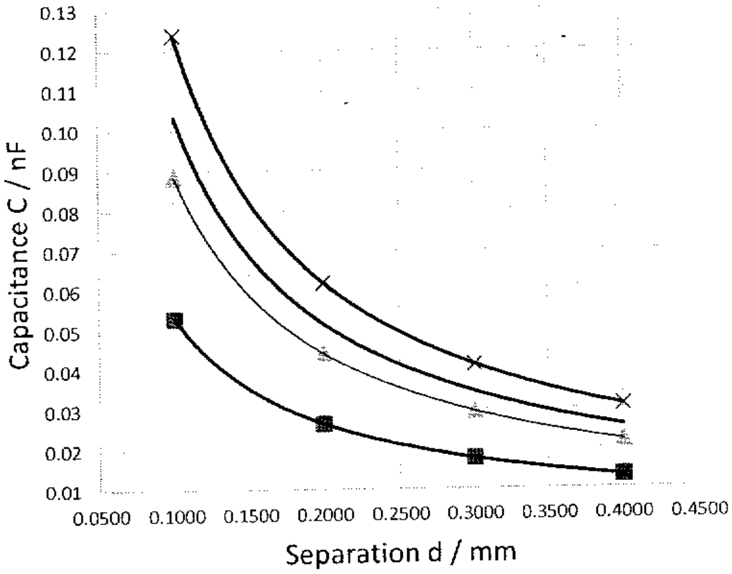
3	
(a)	Upthrust is a force on a partially or fully submerged object , acting in the opposite direction to weight
	Equal in magnitude to the weight of the fluid displaced
(b)	Upthrust $= \rho_{water} V g$ $= (1000)(0.40)(0.50)(9.81)$ $= 1962$ N
	$T_{BE} =$ weight − upthrust $= (950)(9.81) - 1962$ $= 7357.5$ N
	$= 7360$ N (shown)
(c)(i)	Beam is in equilibrium. Taking moments about A, Total clockwise moment = total anticlockwise moment $T_{BE}(3.00\cos 58^\circ) + m_{beam} g\left(\frac{3.00}{2}\cos 58^\circ\right) = T_{CD}(1.24\sin 32^\circ)$ where 1.24 sin 32° = perpendicular distance from CD to O
	$T_{CD} = \frac{(7360)(3.00\cos 58^\circ) + (80.0)(9.81)(1.50\cos 58^\circ)}{1.24\sin 32^\circ}$ $= 18\ 700$ N
(c)(ii)	Net force on bar must be zero in all directions for translational equilibrium
	Possible justification includes • *F* must have an upward component to cancel out the net downward force from T_{CD}, T_{BE}, and the weight of the beam. • *F* must have a rightward component to cancel out the leftward force from T_{CD}.
(c)(iii)	Beam is in equilibrium. Taking moments about D, T_{BE} provides clockwise moment.
	Hence, *F* must provide anticlockwise moment, so the direction of *F* is below AB.

4	
(a)(i)	When the voltmeter reading is zero, the p.d. across AB is equal to the p.d. across the 100 Ω resistor.
	$\frac{x}{l_{AC}} = \frac{100}{100+160}$ $x = \left(\frac{100}{100+160}\right)(90\times10^{-2})$ $= 34.6\times10^{-2}$ m ≈ 35 cm
(ii)	$R_{eff} = \frac{\varepsilon}{I}$ $= \frac{3.0}{0.234}$ $= 12.82\ \Omega$
	$\frac{1}{R_{eff}} = \frac{1}{R_{AC}} + \frac{1}{R+160}$ $\frac{1}{12.82} = \frac{1}{R_{AC}} + \frac{1}{100+160}$ $R_{AC} = 13.49$ $\approx 13.5\ \Omega$
(iii)	If the battery has internal resistance, the terminal potential difference across the battery will be smaller. With the same current, the effective resistance of the external circuit is smaller.
	Hence, the resistance of the resistance wire AC will be a smaller value.

(b)(i)	For half wave rectification, $V_{rms} = \sqrt{\dfrac{\dfrac{V_0^2}{2}\left(\dfrac{T}{2}\right)}{T}}$ $= \dfrac{V_0}{2}$
	$P_{ave} = \dfrac{V_{rms}^2}{R}$ $= \left(\dfrac{V_0}{2}\right)^2\left(\dfrac{1}{R}\right)$ $= \left(\dfrac{12}{2}\right)^2\left(\dfrac{1}{13.5}\right)$ $= 2.7\text{ W}$
(ii)	Sinusoidal waveform with an amplitude of three divisions since the peak voltage is 12 V.
	$T = \dfrac{1}{f}$ $= \dfrac{1}{50}$ $= 0.020\text{ s}$ $= 20\text{ ms}$ Period of each cycle is 4 divisions and three cycles are drawn.
	

5	
(a)(i)	Out of the page
(a)(ii)1.	B_E = 35 μT
(a)(ii)2.	As the d increases (and 1/d tends to zero), the magnetic field due to the wire decreases to 0. Hence the y-intercept is only due to the magnetic field due to the Earth.
(a)(ii)3.	From graph, (140, 80) So this implies $B = B_W + B_E$ at this position.
	So $B_W = 80 - 35 = 45$ μT
	Apply $B_w = \frac{\mu_0 I}{2\pi d}$ $I_W = 2\pi(\frac{1}{140})(45\times10^{-6})(4\pi\times10^{-7})^{-1} = 1.6$ A
(a)(iii)	 Arrows must be labelled in the opposite direction and of the same magnitude. Within 2nd and 4th quadrant.
(b)	Direct current in electromagnet sets up an external magnetic field on the disc
	By Faraday's law, since disc is rotating, there is a rate of change in magnetic flux linkage as the disc enters the region of the external magnetic field.
	This results in an induced emf and a corresponding induced eddy currents in the disc.
	By Lenz's law, these eddy currents will results in a force that oppose the change that is causing it. Hence the velocity of the disc will decrease.

6	
(a)(i)	A photon has an energy which is dependent on its frequency (E = *hf*), which is lower than the work function, hence not sufficient emit the electrons.
	For waves, the energy is dependent on the amplitude/intensity of the wave.
(a)(ii)	A single photon is absorbed by a single electron and the interaction is almost instantaneous.
	For waves, it will take time for the photon to absorb and accumulate sufficient energy to be ejected.
(b)(i)1.	$E = \frac{hc}{\lambda} = \frac{(6.63\times10^{-34})(3.0\times10^{8})}{(680\times10^{-9})}$
	$E = 2.9\times10^{-19}$ J
(b)(i)2.	$I = \frac{P}{A} = \frac{\left(\frac{N}{t}\right)\left(\frac{hc}{\lambda}\right)}{\pi\left(\frac{d}{2}\right)^2}$ $\frac{N}{t} = \frac{(3.2\times10^{3})\pi\left(\frac{1.5\times10^{-3}}{2}\right)^2}{2.9\times10^{-19}}$
	$\frac{N}{t} = 1.9\times10^{16}$ s^{-1}
(b)(ii)	$p_i = \frac{h}{\lambda}\cos 30° = \frac{(6.63\times10^{-34})}{(680\times10^{-9})}\cos 30° = 8.4\times10^{-28}$ kg m s^{-1}
	$F_{\text{on one photon}} = \frac{p_f - p_i}{t} = \frac{(-8.4\times10^{-28})-(8.4\times10^{-28})}{t}$
	$F_{\text{on surface by one photon}} = -\left(\frac{p_f - p_i}{t}\right) = \frac{1.7\times10^{-27}}{t}$
	total force on surface by photons $= -N\left(\frac{p_f - p_i}{t}\right) = (1.9\times10^{16})(1.7\times10^{-27}) = 3.3\times10^{-11}$ N
(b)(iii)	The reflected photons will have a smaller change in momentum, hence the force will be smaller.

7	
(a)i)	$\frac{C_{0.3}}{C_{0.1}} = \frac{d_{0.1}}{d_{0.3}}$ $C_{0.3} = \frac{0.1}{0.3}(0.089) = 0.030nF$
ii)	
	B1 – plot correctly plotted B1 – smooth curve plotted passing through all points
iii)	$C = 0.082nF$
iv)	$C = \varepsilon\frac{A}{d}$ $\varepsilon = \frac{Cd}{A} = \frac{(0.082\times10^{-9})(0.15\times10^{-3})}{1.0\times10^{-4}}$
	$\varepsilon = 1.23\times10^{-10}Fm^{-1}$
b)(i)	When time increases $e^{-t/RC}$ becomes very small, V_c will be very close to V_s
	This will result in an almost zero potential difference and zero current flow
(ii)	$I_R = \frac{V_R}{R}$ $= \frac{V_s}{R}e^{-t/RC}$
(c)(i)	Current flowing in the resistor determine how fast the charge is being discharged
	As the charges decreases, voltage decreases, current decreases and the rate of decrease in charge decreases.
(ii)	- Capacitor can be recharged - Capacitor can release their charge at a much faster rate

	- Capacitor do not lose their charge storage capacity over time
(d)(i)	$C = \frac{Q}{V}$ $Q = CV = (20\times10^{-6})(8) = 1.6\times10^{-4}C$
ii)	$V_c = V_s(1-e^{-t/RC})$ $8 = 12(1-e^{-t/(5)(20\times10^{-6})})$
	$t = 1.10\times10^{-4}s$
iii)	$F = \frac{1}{T}$ $= \frac{1}{1.10\times10^{-4}} = 9.09kHz$
iv) 1.	The lower the resistance, the lower the amount of time the capacitor will take to reach 8.0 V
	Lowering the resistance will decrease the period and increase the frequency
2.	$2000 \le \frac{1}{T}$ $T \le 0.0005s$
	R = 10 and 20 Ω