Assessment Schedule – 2005

Physics: Demonstrate understanding of electrical systems (90523)

Evidence Statement

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
1(a)	**This is a show question** $r = \dfrac{8.06 - 1.18}{0.107}$ $= \dfrac{6.88}{0.107}$ (= 64.299 = 64.3 Ω)		Bottom and top lines correct **OR** Equivalent statement **M2**	
1(b)	The battery has a much lower internal resistance than the solar cell and so a much higher current can be drawn. The terminal voltage of both the battery and the cell are the same so the battery can deliver far more power than the cell.	*ONE correct and relevant statement:* *Typical responses might be:* Lower internal resistance Total resistance (in circuit) is reduced Higher current (drawn from battery).**Watch for contradictory statements.** Voltage across (supplied to) motor will be greater Battery will deliver more power Terminal voltages (of solar cell and battery) the same From data given terminal voltage is 7.41V. **A1**	*Link made between the* lower internal resistance or total resistance and the higher current **OR** lower internal resistance, higher voltage across motor or terminal or circuit or similar **OR** lower internal resistance and greater power (to drive the motor). **M1**	*Link made between the* lower internal resistance and the higher current. **AND** higher voltage (across motor). ——— Terminal voltages the same **AND** current increased. **E1**
1(c)	Around any **closed loop or circuit** the sum of or total or adding the voltages are equal to zero or equivalent statement.	Correct statement. **A1**		

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1(d)	From the outside loop: $8.06 - (0.029 \times r_s) + (0.645 \times 0.14) - 7.50 = 0$ $\Rightarrow r_s = 22.4241$ (= **22 Ω)** Or $T_{terminal} = E - Ir = 7.50 - 0.14 \times 0.645 = 7.4097V$ Therefore $V_r = 0.6503V$ So internal resistance = $\frac{0.6503}{0.029} = 22.4241\ \Omega$		Correct answer. **22 Ω** **M2**	
1(e)	$\tau = CR = 5.00 \times 10^{-3} \times 64.3$ = **0.322 s**	Correct answer. **A2**		
1(f)	As charging progresses, the current in the circuit will decrease and so the internal resistance of the cell will also decrease. This means that the time constant will be decreasing. As the rate at which the current decreases is inversely related to the time constant, this rate will be increasing, hence it will take a shorter time for the capacitor to fully charge. **OR** Increasing V_c means decreasing current in solar cell. This means decreasing current and hence decreasing internal resistance. The reduced internal resistance means a slower drop off in current. (compared to the fixed resistor circuit).	*ONE correct and relevant statement:* Time is shorter (but if followed by a contradictory statement do not allow) internal resistance will decrease current will decrease time constant will be decreasing. **A1**	Time for solar cell is shorter and: *Any ONE of the linkages below gives merit* Decreasing current and hence decreasing internal resistance **OR** decreasing internal resistance means decreasing time constant (τ = RC) **M1**	Time for solar cell is shorter and: Decreasing current and hence decreasing internal resistance to decreasing time constant (τ = RC) and hence shorter charging time. **E1**
			Time for solar cell is shorter and: Increasing V_C means decreasing current in solar cell **OR** Decreasing current and hence decreasing internal resistance **OR** Reduced internal resistance means a slower drop off in current (compared to the fixed resistor circuit). **M1**	Time for solar cell is shorter and: Increasing V_C means decreasing current in solar cell. This means decreasing current and hence decreasing internal resistance The reduced internal resistance means increased current (or a slower drop off in current). **E1**

<table>
<tr><th>Q</th><th>Evidence</th><th>Evidence contributing to Achievement</th><th>Evidence contributing to Achievement with Merit</th><th>Evidence contributing to Achievement with Excellence</th></tr>
<tr><td>2(a)</td><td>$R = \frac{V}{I} = \frac{12}{0.152} = 78.9 = 79\,\Omega$

Note: Units and SF mark for this question</td><td>Correct answer.
A2

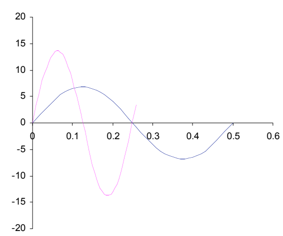
Answer rounded to 2sf PLUS
TWO correct units from
Q1e, 2a, 2c, 2d
A1</td><td></td><td></td></tr>
<tr><td>2(b)</td><td>The coil acts as inductor. When the current is turned on the coil produces a magnetic field. Because there is now a magnetic field where there was none before, there has been an increase in magnetic flux. This change in magnetic flux induces a voltage. The direction of the voltage will act to oppose the increase in magnetic flux and therefore will oppose the supply voltage, hence slowing down the rate at which the current builds up in the circuit.</td><td>ONE correct and relevant statement:
When switched on there has been a change in current.
There has been an increase [change] in magnetic flux [field].
Voltage is induced.
(Induced) voltage opposes battery (voltage).
Back emf produced.

Do not accept opposing or back currents as a relevant statement.</td><td>Explanation correctly includes
EITHER
Faraday's law
Change in current produces a change in magnetic flux
or
Change in magnetic flux (field) induces a voltage
or
Accept $\varepsilon = \frac{\Delta\varphi}{\Delta t}$
as long as terms are explained.

OR
Lenz's law
The direction of the (induced) voltage will act to oppose the increase in magnetic flux or increase in current
or
The direction of the (induced) voltage will act to oppose the battery (voltage)
or
$\varepsilon = (-)\frac{\Delta\varphi}{\Delta t}$
Only if (-) is explained
If they use back currents in their linkages, they cannot get Merit.
M1</td><td>Complete explanation correctly includes BOTH Faraday's and Lenz's laws.

Change in current produces a change in magnetic flux
Change in magnetic flux (field) induces a voltage
The direction of the voltage will act to oppose the increase in magnetic flux or the battery voltage or the increase in current.</td></tr>
</table>

		A1		**E1**

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
2(c)	$I_{max} = 0.152$ A Time constant = time for current to reach 63% of I_{max} (= 0.63 × 0.152 = 0.0958 A) From graph this occurs at t = 2.0 ms Hence $\tau = 0.0020 \pm 0.002$ s But $\tau = \frac{L}{R} = \frac{L}{79}$ $L = 79 \times 0.0020 = 0.158 = 0.16$ H ***or*** slope of line is approx $\frac{0.14}{2 \times 10^{-3}} = 70$ (accept ± 10) $L = \frac{V}{slope} = \frac{12}{70} = 0.17\text{H}$ **Watch consistency with 2(a).**		*Correct time constant* *τ =0.002 s (2 ms)* ***or*** *consistent L from incorrect value of τ.* *(Must be a reasonable value 0.0020 ± 0.0002 or* *2.0 ± 0.2)* *Eg* *157.89 H (from τ =2 s)* ***or*** Correct slope 70 ± 10 **M2**	Correct answer. **E2**
2(d)	$\phi = B \times A = 0.21 \times 5.20 \times 10^{-3}$ $= 1.092 \times 10^{-3} = 1.1 \times 10^{-3}$ Wb ***or*** $\phi = B \times A = 0.21 \times 5.20 \times 10^{-3} \times 500$ $= 1.092 \times 10^{-3} \times 500$ $= 0.546 = 0.55$ Wb	Correct answer. 1.1×10^{-3} Wb ***or*** 0.55 Wb **A2**		
2(e)	$V = -\frac{\Delta\varphi}{\Delta t} = -\frac{0.546}{t}$ t = time to turn from vertical to horizontal = ¼ period. $T = 0.5$ s, so $t = 0.125$ s $\Rightarrow \quad V = \frac{0.546}{0.125} = 4.368 \text{ V} = 4.4 \text{ V}$	Correct time (0.125 s) ***or*** Incorrect time but correct flux change. (For instance 8.72×10^{3} V would be A_2.) **A2**	Correct answer. **Look for consistency from 2(d).** **M2**	
2(f)		**EITHER** voltage doubled (between 13 V and 15 V) Bottom or top would be sufficient **OR** period halved. Does not need to be exact but intention of halving is indicated. **A1**	**BOTH** voltage doubled **AND** period halved. **M1**	

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(a)	$V_{max} = V_{rms} \times \sqrt{2} = 6.00 \times \sqrt{2}$ $= 8.48528$ **8.49 V**	Correct answer. **A2**		
3(b)	As this is an AC circuit the voltages across the components are not in phase with each other, they have to be added vectorially. If use $V_S = \sqrt{V_R^2 + (V_C - V_L)^2}$ without some relevant explanation then **N**	*ONE correct and relevant statement*: voltages out of phase **OR** voltages added vectorially. **A1** **OR** shows a labelled LRC vector diagram (V_L, V_R, V_C not in the correct order) **A1**	voltages out of phase **AND** voltages added vectorially. **M1** **OR** shows a labelled LRC diagram. (must have V_L, V_R, V_C in the correct order) If V_S is shown it must lag the current or V_R. **M1**	
3(c)	**This is a show question** $I = \frac{V_R}{R} = \frac{5.99}{18.5} = 0.324 \text{ A} = 324 \text{ mA}$ **Note: V_R must be 5.99 (not 6.00)** **OR** use V_L / X_L and $X_L = \omega L$ $X_L = 2\pi fL = 2\pi \times 100 \times 3.6 \times 10^{-3}$ $= 2.26\ \Omega$ $I = \frac{V_L}{X_l} = \frac{0.733}{2.26} = (0.324 \text{ A})$ $(= 324 \text{ mA})$	Correct answer. **A2**		

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(d)	**This is a show question** $X_C = \frac{V_C}{I} = \frac{0.808}{0.324} = 2.494\ \Omega$ $X_C = \frac{1}{2\pi f C}$ $C = \frac{1}{2\pi f X_C}$ $= \frac{1}{2\pi \times 100 \times 2.494}$ $= 6.38 \times 10^{-4}$ $= 638\ \mu F$	Either $X_C = \frac{V_C}{I}$ *or* $X_C = \frac{1}{2\pi fC}$ ***or*** $X_c = \frac{1}{\omega C}$ seen in their working (alone or substituted into). **A2**	X_C correct (= 2.494 Ω) ***and*** $X_C = \frac{1}{2\pi fC}$ given or correctly substituted into. **M2**	Correct rearrangement $C = \frac{1}{2\pi \times 100 \times 2.494}$ **E2**
3(e)	**This is a show question** Resonant frequency when $X_C = X_L$ For this capacitor and inductor: $\frac{1}{2\pi f C} = 2\pi f L$ rearranging gives $f^2 = \frac{1}{4\pi^2 LC}$ $f = \frac{1}{2\pi\sqrt{LC}}$ $= \frac{1}{2\pi\sqrt{6.38 \times 10^{-4} \times 3.6 \times 10^{-3}}}$ $= 105.0167$ (Hz) (= 105 Hz) **If the following is used there must be some relevant discussion given. Otherwise N.** $f = \frac{1}{2\pi\sqrt{LC}}$	*Any condition sufficient for resonance* $X_C = X_L$ $V_C = V_L$ X_L and X_C cancel out (or 180° out of phase) $V_S = V_R$ Minimum impedance Maximum current. **A2**	*The following statement given* $\frac{1}{2\pi f C} = 2\pi f L$ **M2**	*Merit plus correct rearrangement and substitution into* $f = \frac{1}{2\pi\sqrt{LC}}$ $f = \frac{1}{2\pi\sqrt{6.38 \times 10^{-4} \times 3.6 \times 10^{-3}}}$ $f = \frac{1}{9.522 \times 10^{-3}}$ (= 105 Hz) **E2**

Q	Evidence	Evidence contributing to Achievement	Evidence contributing to Achievement with Merit	Evidence contributing to Achievement with Excellence
3(f)	When metal is brought close to the detector, the inductance of the inductor increases slightly. This has the effect of reducing the resonant frequency of the circuit, bringing it closer to the AC supply frequency. As a result the current in the circuit will increase to peak when the resonant frequency is 100 Hz. This will be shown in the circuit by an increased ammeter reading.	*ONE correct and relevant statement.* *Typically statements could be* The inductance of the inductor changes **OR** The resonant frequency of the circuit changes (because of the metal) **OR** The current increases. **A1**	*Links inductance changing and resonant frequency changing and reduced f_o* *Typically linkages could be* The inductance of the inductor changes, (reduces) lowering the resonant frequency (of the circuit) **OR** The inductance of the inductor changes. This causes X_C and X_L to be closer in value (or V_C and V_L to be closer in value). **OR** X_C and X_L are closer in value (or V_C and V_L are closer in value) so impedance is smaller, therefore the current increases. **M1**	The explanation clearly links the change in inductance, change in resonant frequency and increased current. The inductance of the inductor **increases**. This causes X_C and X_L to be closer in value (or V_C and V_L to be closer in value). Therefore the current will become larger (because the impedance is smaller). **E1**

Question Analysis:

Italics indicates that this question has already appeared in the table so should not count towards total opportunities.

	Qn	A	M	E
C1	8	1(c) 2(a) 2(f) *3(b) 1(b), 1(f) 2(b) 3(f)*	1(f) 3(b) *1(b) 1(f)) 2(b) 2(f) 3(f)*	1(b) 1(f) 2(b) 3(f)
C2	11	1(e) 2(a) 2(d) 3(a) 3(c) *2(e) 3(d) 3(e)*	1(a) 1(d) 2(e) *2(c) 3(d) 3(e)*	2(c) 3(d) 3(e)

Judgement Statement

Criterion 1

Achievement	Achievement with Merit	Achievement with Excellence
THREE opportunities answered at Achievement level or higher. 3 × A1	FIVE opportunities answered with TWO at Merit level or higher. 2 × M1 *plus* 3 × A1	SIX opportunities answered with ONE at Excellence level and TWO at Merit level or higher. 1 × E1 *plus* 2 × M1 *plus* 3 × A1

Criterion 2

Achievement	Achievement with Merit	Achievement with Excellence
FOUR opportunities answered at Achievement or higher. 4 × A2	SIX opportunities answered with TWO at Merit level or higher. 2 × M2 *plus* 4 × A2	SEVEN opportunities answered with ONE at Excellence level and TWO at Merit level or higher. 1 × E2 *plus* 2 × M2 *plus* 4 × A2