JANUARY 1995 PHYSICS 12 PROVINCIAL EXAMINATION
KEY AND SCORING GUIDE

ITEM CLASSIFICATION

TOPICS:
1. Kinematics and Dynamics
2. Energy and Momentum
3. Equilibrium
4. Circular Motion and Gravitation
5. Electrostatics and Circuitry
6. Electromagnetism
7. Quantum Mechancis
8. Fluid Theory
9. AC Circuitry and Electronics

PART A: MULTIPLE-CHOICE

Q	C	T	K	S	CGR	Q	C	T	K	S	CGR
1.	K	1	C	2	I B 1	16.	K	5	C	2	VI A 4
2.	K	1	C	2	I B 5	17.	K	5	A	2	VI A 2
3.	U	1	A	2	I C 6, 5	18.	U	5	D	2	VI A 6
4.	U	1	D	2	II A 6, 5	19.	U	5	C	2	VI B 2
5.	U	1	A	2	II B 5, 6	20.	U	5	C	2	VI B 3
6.	K	2	D	2	III A 1	21.	U	5	C	2	VII A 7
7.	U	2	D	2	III B 2, C 7	22.	U	5	B	2	VII B 2
8.	H	2	B	2	III C 9, A 4	23.	U	5	C	2	VII A 8
9.	U	3	C	2	IV A 3	24.	H	5	A	2	VII A 10, 11
10.	D E L E T E D				IV A 1, B 5	25.	K	6	B	2	VIII A 1, 2
11.	H	3	A	2	IV B 8, 3	26.	U	6	C	2	VIII A 2, 3
12.	K	4	B	2	V B 9	27.	U	6	B	2	VIII A 6
13.	U	4	D	2	V A 6, II B 5	28.	K	6	B	2	VIII B 8
14.	U	4	B	2	V B 6	29.	U	6	D	2	VIII B 2
15.	U	4	C	2	V B 14	30.	U	6	D	2	VIII B 13, 14

PART B: WRITTEN-RESPONSE

Q	B	C	T	S	CGR
1.	1	H	1	7	II B 6, A 2
2.	2	U	2	7	III C 9, 8
3.	3	U	3	7	IV B 8
4a.	4	U	4	5	V B 6
4b.	5	U	4	4	V B 6
5.	6	U	5	7	VII A 6, 11
6.	7	U	6	7	VIII A 5, 8
7.	8	H	6	4	VIII B 10 VII A 11

PART C: ELECTIVE TOPICS

Only **one** of the following sections will be chosen. Score only **one** set of boxes: (9, 10, 11) **or** (12, 13, 14) **or** (15, 16, 17). Maximum possible score for Part C is 12.

	Q	**B**	**C**	**T**	**S**	**CGR**
Section I	1.	9	U	7	3	II A 14
	2.	10	U	7	4	II B 6
	3.	11	U	7	5	II A 9

or

	Q	**B**	**C**	**T**	**S**	**CGR**
Section II	1.	12	U	8	3	III A 9
	2.	13	U	8	4	III B 5
	3.	14	U	8	5	III A 13

or

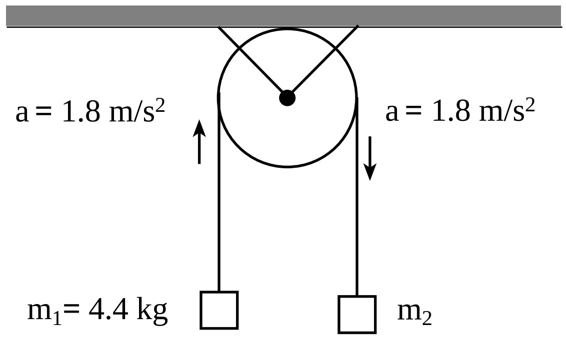
	Q	**B**	**C**	**T**	**S**	**CGR**
Section III	1.	15	U	9	3	I A 7
	2.	16	U	9	4	I C 5, B 3
	3.	17	U	9	5	I A 3, 5

Multiple–choice	=	60 (30 questions)
Written–response	=	60 (10 questions)
Total	**=**	**120 marks**

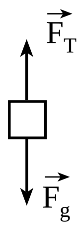
LEGEND:

Q = Question | **C** = Cognitive level | **T** = Topic
K = Keyed response | **S** = Score | **CGR** = Curriculum Guide Reference
B = Boxed response

1. The diagram shows a 4.4 kg mass connected by a string to an unknown mass over a frictionless pulley. The system accelerates at 1.8 m/s^2 in the direction shown.



(a) Draw and label a free body diagram for the 4.4 kg mass. **(2 marks)**



1 mark

1 mark

b) Calculate the tension in the string. **(2 marks)**

$$\text{net } F = ma$$

$$F_T - F_{g_1} = m_1 a \qquad \leftarrow \textbf{1 mark}$$

$$F_T - 4.4(9.8) = 4.4(1.8)$$

$$F_T = 51.0 \text{ N} \qquad \leftarrow \textbf{1 mark}$$

c) Find mass m_2. **(3 marks)**

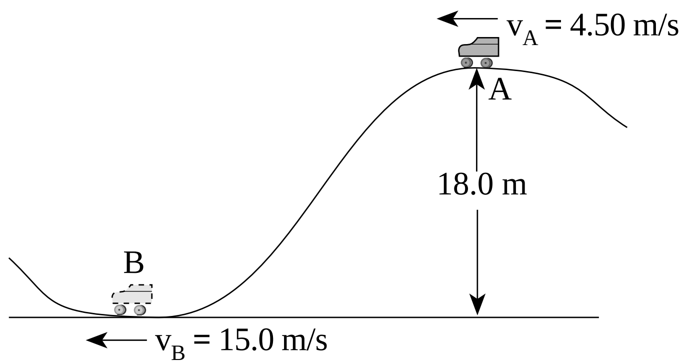
$$\text{net } F = ma$$

$$F_g - F_T = m_2 a \qquad \leftarrow \textbf{1}\tfrac{1}{2} \textbf{ marks}$$

$$m_2(9.8) - 51.0 = m_2(1.8) \qquad \leftarrow \textbf{1 mark}$$

$$m_2 = 6.38 \text{ kg} \qquad \leftarrow \tfrac{1}{2} \textbf{ mark}$$

2. A 250 kg roller coaster car travels past points A and B with speeds shown in the diagram below. How much heat energy is produced between these points? **(7 marks)**



$$E_A = E_B$$

$$E_{P_A} + E_{K_A} = E_{P_B} + E_{K_B} + E_h \quad \leftarrow \textbf{ 2 marks}$$

$$mgh_A + \frac{1}{2}mv_A{}^2 = mgh_B + \frac{1}{2}mv_B{}^2 + E_h \quad \leftarrow \textbf{ 2 marks}$$

correct theory 4 marks

$$250\,\text{kg}\cdot 9.8\,\text{m/s}^2\cdot 18\,\text{m} + \frac{1}{2}\cdot 250\,\text{kg}\cdot(4.5\text{ m/s})^2 = 0 + \frac{1}{2}\cdot 250\,\text{kg}\cdot(15\text{ m/s})^2 + E_h \quad \leftarrow \textbf{ 1 mark}$$

$$\left.\begin{aligned} &44\ 100\ \text{J} + 2\ 531\ \text{J} = 28\ 125\ \text{J} + E_h \\ &46\ 631\ \text{J} = 28\ 125\ \text{J} + E_h \end{aligned}\right\} \textbf{ 1 mark}$$

$$\therefore E_h = \underline{1.85\times 10^4\ \text{J}} \qquad (18.5\ \text{kJ}) \quad \leftarrow \textbf{ 1 mark}$$

Alternate Solution

If no heat loss

$$v^2 = v_0{}^2 + 2ad$$

$$= 4.5^2 + 2(9.8)(18.0)$$

$$v = 19.3 \text{ m/s}$$

2 marks

$\therefore$ Max E_K possible at B

$$E_K = \frac{1}{2}\ mv^2$$

$$= \frac{1}{2}(250)(19.3)^2$$

$$= 4.66 \times 10^4 \text{ J}$$

Actual E_K at B

$$E_K = \frac{1}{2}\ mv_0{}^2$$

$$= \frac{1}{2}(250)(15.0)^2$$

$$= 2.81 \times 10^4 \text{ J}$$

3 marks

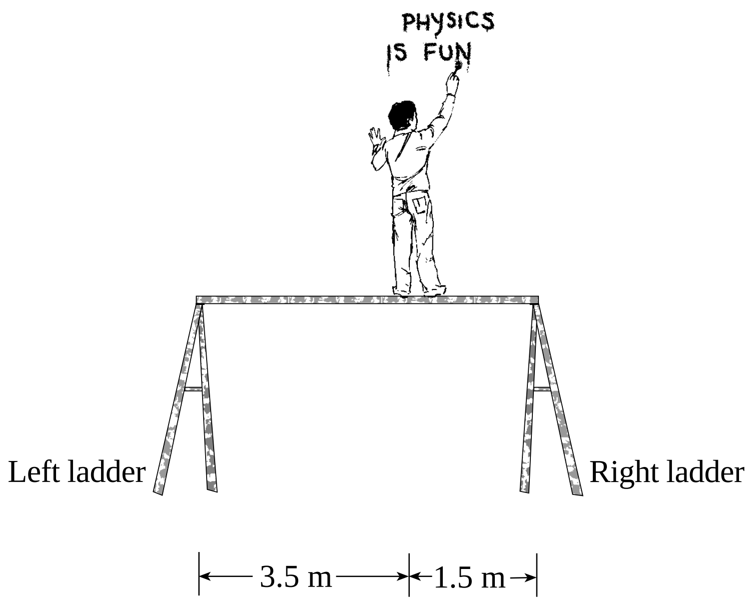
$$\therefore E_H = \Delta E_K$$

$$= (4.66 - 2.81) \times 10^4$$

$$= 1.85 \times 10^4 \text{ J}$$

2 marks

3. A 75 kg painter stands on a uniform 5.0 m board of mass 16 kg supported horizontally by two ladders. Find the forces exerted by each ladder on the board. **(7 marks)**



$$5.0F_R = 75(9.8)(3.5) + 16(9.8)(2.5) \quad \leftarrow \textbf{3 marks}$$

$$5.0F_R = 2\,573 + 392$$

$$\boxed{F_R = 593\text{ N}} \quad \leftarrow \textbf{1 mark}$$

OR

$$\left.\begin{aligned} \Sigma F_Y &= 0_1 \text{ for } F_R = 593\text{ N} \\ F_L + F_R &= F_B + F_P \\ F_L &= F_B + F_P - F_R \end{aligned}\right\} \textbf{2 marks}$$

$$= 157 + 735 - 593$$

$$= 892 - 593$$

$$\boxed{F_L = 299\text{ N}} \quad \leftarrow \textbf{1 mark}$$

$$5.0F_L = 75(9.8)(1.5) + 16(9.8)(2.5) \quad \leftarrow \textbf{2 marks}$$

$$5.0F_L = 11.3 + 392$$

$$\boxed{F_L = 299\text{ N}} \quad \leftarrow \textbf{1 mark}$$

4. a) A satellite is placed in circular orbit at an altitude of 4.8×10^5 m above Earth's surface. What is the satellite's orbital period? **(5 marks)**

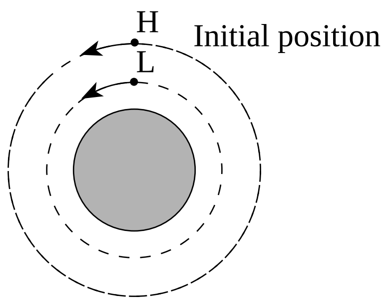
$$F_c = F_g$$

$$\frac{m 4\pi^2 r}{T^2} = \frac{Gmm}{r^2} \qquad \leftarrow \textbf{3 marks}$$

$$T = \sqrt{\frac{4\pi^2 r^3}{Gm}} \qquad \leftarrow \textbf{1 mark}$$

$$T = 5.7 \times 10^3 \text{ s} \qquad \leftarrow \textbf{1 mark}$$

b) (i) As shown in the diagram below, two satellites pass over the same point on Earth's surface. Satellite H is in a higher orbit than satellite L.



Which satellite, H or L, completes one orbit first? (Circle one) **(1 mark)**

A. satellite H

B. satellite L

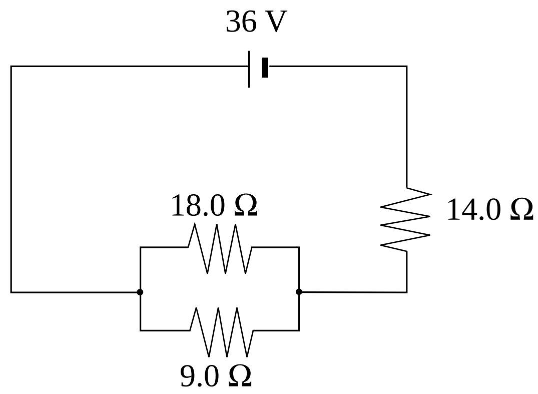
(ii) Using principles of physics, explain your answer. **(3 marks)**

L completes one orbit first. The stronger gravitational field lower down requires a higher velocity to maintain a stable orbit.

OR

Using (Keplar's Third Law) $R^3 \propto T^2$, the smaller the radius of orbit, the shorter the period. Thus, L completes its orbit first.

5. What is the power dissipated in the 9.0 Ω resistor in the following circuit? **(7 marks)**



$$\frac{1}{R_{11}} = \frac{1}{18.0} + \frac{1}{9.0}$$

$R_{11} = 6.0\,\Omega$ ← **1 mark**

$R_{Total} = 20\,\Omega$ ← **1 mark**

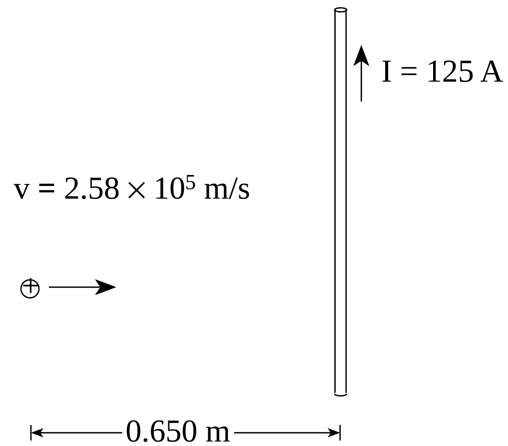
$I_{Total} = \frac{36}{20} = 1.8\text{ A}$ ← **1 mark**

$V_{9.0\Omega} = 36 - (14)(1.8) = 10.8\text{ V}$ ← **2 marks**

$P_{9.0\Omega} = \frac{V^2}{R} = \frac{10.8^2}{9.0} = 13\text{ W}$ ← **2 marks**

6. A proton is traveling at 2.58×10^5 m/s towards a conductor carrying a current of 125 A. What is the magnitude of the magnetic force acting on the proton 0.650 m from the conductor?

(7 marks)



$$F = Bqv \qquad \leftarrow \textbf{1 mark}$$

$$= \left(\frac{\mu_0 I}{2\pi d}\right) qv \qquad \leftarrow \textbf{2 marks}$$

$$= \frac{4\pi \times 10^{-7}(125)\left(1.6 \times 10^{-19}\right)2.58 \times 10^5}{2\pi(0.650)} \qquad \leftarrow \textbf{3 marks}$$

$$= \frac{6.48 \times 10^{-18}}{4.08 \times 10}$$

$$F = 1.6 \times 10^{-18} \text{ N} \qquad \leftarrow \textbf{1 mark}$$

7. When an electric drill turns at normal operating speeds, there is little heat produced in the motor windings. When drilling harder material, the drill motor turns much slower than normal and overheats. Using principles of physics, give an explanation for the increased heat in the windings.
(4 marks)

When the motor turns at normal operating speeds, the rotating coils act as a generator and produce a back emf. This back emf reduces the effective voltage across the coil so only a small current flows, producing a small amount of heat $\left(I^2R\right)$. When the motor slows, the generator effect, and thus the back emf, is reduced. This means more of the line voltage is applied to the small resistance of the armature resulting in more current and in turn the motor produces more heat.

PART C: ELECTED TOPICS

SECTION I: Quantum Mechanics

1.	What is the wavelength of a proton traveling at 2.70×10^5 m/s ?	**(3 marks)**

$$\lambda = \frac{h}{p} = \frac{h}{mv} \qquad \leftarrow \quad \textbf{1}\tfrac{1}{2}\ \textbf{marks}$$

$$\left.\begin{aligned} &= \frac{\left(6.63 \times 10^{-34}\right)}{\left(1.67 \times 10^{-27}\right)\left(2.70 \times 10^{5}\right)} \\ \lambda &= 1.47 \times 10^{-12}\ \text{m} \end{aligned}\right\} \quad \textbf{1}\tfrac{1}{2}\ \textbf{marks}$$

2.	An ionized lithium atom has one electron and a nucleus with three protons and four neutrons. What is the energy of an electron in the first excited state (n = 2) ?	**(4 marks)**

$$E_A = \frac{-13.6\left(Z^2\right)}{n^2} \qquad \leftarrow \ \textbf{1 mark}$$

$$= \frac{-13.6\left(3^2\right)}{2^2} \qquad \leftarrow \ \textbf{2 marks}$$

$$= -30.6\ \text{eV} \qquad \leftarrow \ \textbf{1 mark}$$

3.	Light shines on a metal surface that has a work function of 2.60 eV . The light has a wavelength of 400 nm . What is the maximum speed of photoelectrons ejected from the surface by this light?	**(5 marks)**

$$E_{K_{max}} = \frac{hc}{\lambda} - W_0 \qquad \leftarrow \quad \textbf{1 mark}$$

$$= \frac{4.14 \times 10^{-15}\ \text{eVs} \cdot 3.00 \times 10^{8}\ \text{m/s}}{4.00 \times 10^{-7}\ \text{m}} - 2.60\ \text{eV} \qquad \leftarrow \quad \textbf{1}\tfrac{1}{2}\ \textbf{marks}$$

$$= 3.105\ \text{eV} - 2.60\ \text{eV}$$

$$= 0.51\ \text{eV} \cdot 1.6 \times 10^{-19}\ \frac{\text{J}}{\text{eV}} \qquad \leftarrow \quad \textbf{1 mark}$$

$$= 8.1 \times 10^{-20}\ \text{J}$$

$$\left.\begin{aligned} \therefore\ \upsilon &= \left(\frac{2E_K}{m}\right)^{\frac{1}{2}} \\ &= \left(\frac{2 \cdot 8.1 \times 10^{-20}\ \text{J}}{9.11 \times 10^{-31}\ \text{kg}}\right)^{\frac{1}{2}} \end{aligned}\right\} \quad \textbf{1}\tfrac{1}{2}\ \textbf{marks}$$

$$= 4.2 \times 10^{5}\ \text{m/s}$$

END OF SECTION I: Quantum Mechanics

SECTION II: Fluid Theory

1. A block of wood floats in water with $1.71\,\mathrm{m}^3$ of it's volume submerged. Find the buoyant force acting on the block of wood. **(3 marks)**

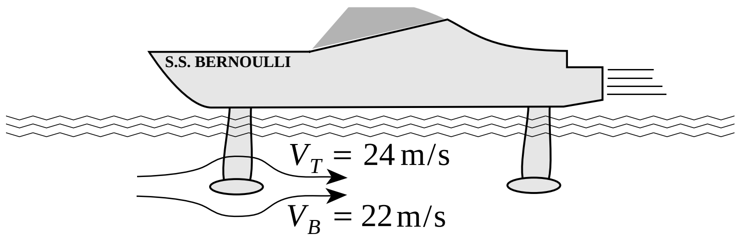
$$
\begin{aligned}
F_B &= \rho V g && \leftarrow \textbf{1 mark} \\
&= 1\,000 \times 1.71 \times 9.8 && \leftarrow \textbf{1}\tfrac{\mathbf{1}}{\mathbf{2}}\ \textbf{marks} \\
&= 1.68 \times 10^4\,\mathrm{N} && \leftarrow \tfrac{\mathbf{1}}{\mathbf{2}}\ \textbf{mark}
\end{aligned}
$$

2. A sealed cylinder contains $0.82\,\mathrm{m}^3$ of an ideal gas at $18^\circ\mathrm{C}$. When the cylinder is heated, a piston allows the gas to expand at constant pressure to a new volume of $0.93\,\mathrm{m}^3$. Find the new temperature of the gas. **(4 marks)**

$$
\left.
\begin{aligned}
&\frac{V_1}{T_1} = \frac{V_2}{T_2} \\
&\frac{0.82}{\underset{\substack{\uparrow \\ \textbf{1 mark}}}{(273+18)}} = \frac{0.93}{T_2}
\end{aligned}
\right\}\ \textbf{2 marks}
$$

$$T_2 = 330\ \mathrm{K} = 57^\circ\mathrm{C} \quad \leftarrow \textbf{1 mark}$$

3. The diagram shows a hydrofoil, a vessel supported by an underwater "wing". Water flows over the top surface of the wing at 24 m/s and under the bottom surface at 22 m/s. Find the pressure difference between the surfaces of the wing. **(5 marks)**



$$P_T + \rho g h_T + \frac{1}{2}\rho v_T{}^2 = P_B + \rho g h_B + \frac{1}{2}\rho v_B{}^2 \quad \leftarrow \textbf{1 mark}$$

$$\rho g h_T = \rho g h_B = 0 \quad \leftarrow \textbf{1 mark}$$

$$P_B - P_T = \frac{1}{2}\rho v_T{}^2 - \frac{1}{2}\rho v_B{}^2 \quad \leftarrow \textbf{1 mark}$$

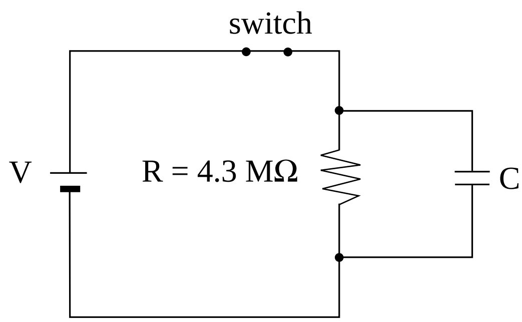
$$\Delta P = \frac{1}{2} \times 1\,000\left(24^2 - 22^2\right) \quad \leftarrow \textbf{1 mark}$$

$$= 4.6 \times 10^4 \text{ P}_\text{a} \quad \leftarrow \textbf{1 mark}$$

END OF SECTION II: Fluid Theory

SECTION III: AC Circuitry and Electronics

1. The diagram below shows a circuit in which the switch has been closed for a long time.



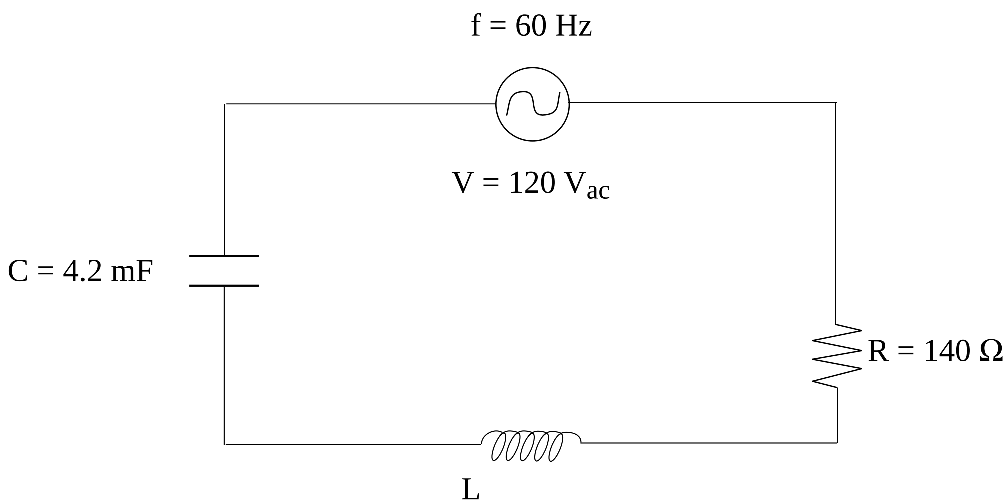
When the switch is opened, it takes 8.0 s for the voltage across the capacitor to drop to 37% of the battery voltage V. What is the capacitance C of the capacitor? **(3 marks)**

$\tau = RC$ ← **1 mark**

$8.0 = \left(4.3 \times 10^6\right) C$ ← **1 mark**

$C = 1.9\ \mu F$ ← **1 mark**

2. The diagram below shows an LRC circuit that has a resonant frequency of 60 Hz.



What is the inductive reactance for this circuit at the resonant frequency? **(4 marks)**

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC}}$$ ←**1 mark**

$$L = \frac{1}{4\pi^2\left(4.2\times10^{-3}\right)60^2}$$ ←**1 mark**

$$L = 1.68\times10^{-3}\,\text{H}$$ ←**1 mark**

$$X_L = 2\pi f L = 0.63\ \Omega$$ ←**1 mark**

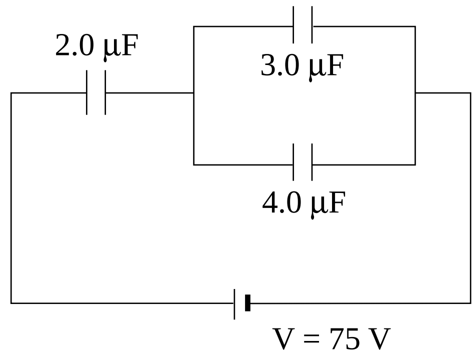
OR

$$X_L = X_C = \frac{1}{2\pi FC}$$ ← **2 marks**

$$X_L = \frac{1}{2\pi(60)\left(4.2\times10^{-3}\right)}$$ ← **1 mark**

$$X_L = 0.63\ \Omega$$ ← **1 mark**

3. What is the maximum charge on the $3.0\ \mu F$ capacitor? **(5 marks)**



$$\frac{1}{C_T} = \frac{1}{2.0} + \frac{1}{3.0 + 4.0}$$

$$C_T = 1.56\ \mu F$$ ← **2 marks**

$$Q_T = C_T V_T$$

$$= 1.17 \times 10^{-4}\ C$$ ← **1 mark**

$$V_{3_{\mu F}} = \frac{Q_T}{C_{11}} = 16.7\ V$$ ← **1 mark**

$$Q_{3_{\mu F}} = C_{3_{\mu F}} V$$

$$= 5.0 \times 10^{-5}\ C$$ ← **1 mark**

END OF KEY