Physics 12

January 1997 Provincial Examination

ANSWER KEY / SCORING GUIDE

TOPICS:
1. Kinematics and Dynamics
2. Energy and Momentum
3. Equilibrium
4. Circular Motion and Gravitation
5. Electrostatics and Circuitry
6. Electromagnetism
7. Quantum Physics
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	A	2	I B1	16.	K	5	D	2	VI A4
2.	K	1	C	2	I B5	17.	U	5	C	2	VII A2, A4, A6
3.	U	1	B	2	I A1	18.	U	5	D	2	VI A6
4.	U	1	B	2	II A2	19.	U	5	C	2	VI B3
5.	U	1	B	2	II B6	20.	K	5	D	2	VII B2
6.	K	2	D	2	III A7	21.	U	5	C	2	VII A10
7.	U	2	D	2	III C9, C2	22.	U	5	A	2	VII A11, A6
8.	H	2	B	2	III A4	23.	U	5	C	2	VII A8
9.	U	2	A	2	IV B6	24.	K	6	D	2	VIII A2
10.	U	3	C	2	IV A3	25.	H	6	B	2	VIII A6, III A4
11.	K	4	D	2	V B9	26.	U	6	B	2	VIII A8
12.	U	4	C	2	V A4	27.	K	6	D	2	VIII B14
13.	U	4	B	2	V B15	28.	U	6	D	2	VIII A9
14.	U	4	C	2	V B3	29.	U	6	D	2	VIII B7
15.	H	4	C	2	V A6 B6	30.	H	6	C	2	VIII B8, A2

PART B: Written Response

Q	B	C	T	S	CGR
1.	1	U	1	9	I C 6, C1-4
2.	2	U	2	7	III D 2
3.	3	U	3	7	IV B 8, A3
4.	4	U	4	7	V B6
5.	5	U	5	7	VII A7, A11
6.	6	U	6	7	VIII A9, A4
7.	7	H	5	4	VII B4, 2

PART C: Elective Topics

Only **one** of the following sections will be chosen. Score only **one** set of boxes: (8, 9, 10) **or** (11,12,13) **or** (14, 15, 16). Maximum possible score for Part C is 12.

	Q	**B**	**C**	**T**	**S**	**CGR**
Section I	1.	8	U	7	3	II B6
	2.	9	U	7	4	II A6, III C10
	3.	10	U	7	5	II A9

or

	Q	**B**	**C**	**T**	**S**	**CGR**
Section II	1.	11	U	8	3	III A2
	2.	12	U	8	4	III B7
	3.	13	U	8	5	III A13

or

	Q	**B**	**C**	**T**	**S**	**CGR**
Section III	1.	14	U	9	3	I A7
	2.	15	U	9	4	I A5
	3.	16	U	9	5	I C5, B3

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (10 questions)
Total	**=**	**120 marks**

LEGEND:

Q = Question Number | **C** = Cognitive Level | **T** = Topic
K = Keyed Response | **S** = Score | **CGR** = Curriculum Guide Reference
B = Score Box Number

1. A projectile is launched over level ground at $85\ \text{m/s}$, $25°$ above the horizontal. Air resistance may be ignored.

   a) Calculate the range (horizontal distance) of the projectile. **(5marks)**

$$v_{y_i} = v\sin\theta$$
$$= 85\ \text{m/s}\cdot\sin 25$$
$$= 35.9\ \text{m/s}$$
$$v_x = v\cos\theta$$
$$= 85\ \text{m/s}\cdot\cos 25$$
$$= 77.0\ \text{m/s}$$
$$t = \frac{-v_{y_i} - v_{y_i}}{a}$$
$$= \frac{-35.9\ \text{m/s} - 35.9\ \text{m/s}}{-9.8\ \text{m/s}^2}$$

$\leftarrow$ **4 marks**

$$= 7.33\ \text{s}$$
$$d_x = v_x \cdot t$$
$$= 77.0\ \text{m/s}\cdot 7.33\ \text{s}$$
$$= 5.6\times 10^2\ \text{m}$$

$\leftarrow$ **1 mark**

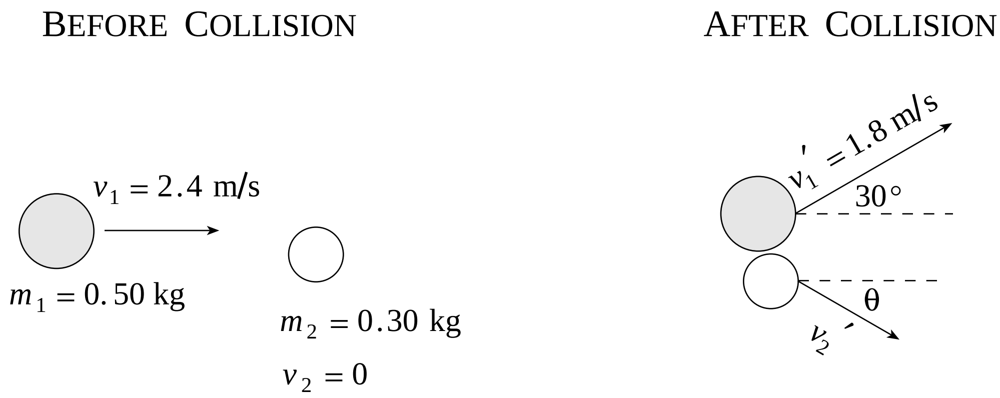
   b) Using principles of physics, comment on the horizontal and vertical components of the projectile's velocity and acceleration during the flight. **(4 marks)**

The horizontal component of velocity remains constant. There is no horizontal acceleration (assuming air resistance is negligible). $\leftarrow$ **2 marks**

The vertical component of velocity changes continuously during the flight. $\leftarrow$ **1 mark**

The vertical acceleration is constant at $9.8\ \text{m/s}^2$, downward, throughout the flight. $\leftarrow$ **1 mark**

2. Two steel pucks collide as shown in the diagram below.



Determine the speed and direction (angle θ) of the 0.30 kg puck after the collision. **(7marks)**

$p = p'$

$p = m_1 v_1$

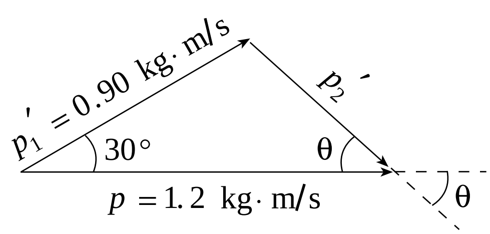
$= 0.50 \text{ kg} \cdot 2.4 \text{ m/s}$

$= 1.2 \text{ kg} \cdot \text{m/s}$

$p = m_1 v_1'$

$= 0.50 \text{ kg} \cdot 1.8 \text{ m/s}$

$= 0.90 \text{ kg} \cdot \text{m/s}$ ← **1 mark**



← **3 marks**

By cosine law:

$$\left(p_2'\right)^2 = \left(p_1'\right)^2 + p^2 - 2p_1' p \cos 30°$$

$$= 0.90^2 + 1.2^2 - 2 \cdot (0.9) \cdot (1.2) \cdot \cos 30°$$

$$= 0.379$$

$\therefore p_2' = 0.616 \text{ kg} \cdot \text{m/s}$ ← **1 mark**

$$\therefore v_2' = \frac{p_2'}{m}$$

$$= \frac{0.616 \text{ kg} \cdot \text{m/s}}{0.30 \text{ kg}}$$

$= 2.1 \text{ m/s}$ ← **1 mark**

By sine law:

$$\frac{\sin\theta}{0.90} = \frac{\sin 30°}{0.616}$$

$\therefore \theta = 47°$ ← **1 mark**

Alternate Solution:

Component Method:

$$\Sigma Px:\ m_1 v_{1x} = m_1 v'_{1x} + m_2 v'_{2x}$$

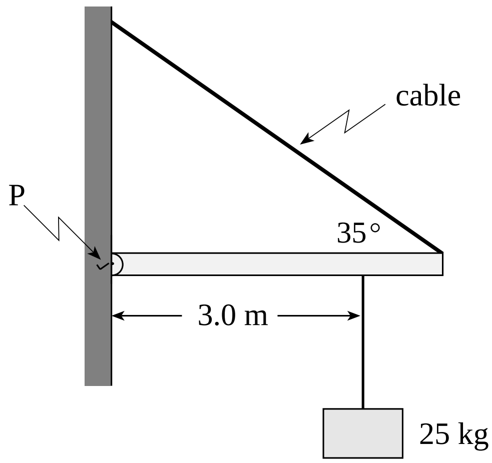
$$\Sigma Py:\ m_1 v_{1y} = m_1 v'_{1y} + m_2 v'_{2y} \qquad \leftarrow \textbf{2 marks}$$

$$\left.\begin{aligned}
\Sigma Px &= 1.2 = .5 \times 1.8 \cos 30 + .3 v_{2x} \\
v_{2x} &= 1.40 \text{ m/s} \\
\Sigma Py &= 0 = .5 \times 1.8 \sin 30 + .3 v_{2y} \\
v_{2y} &= -1.50 \text{ m/s}
\end{aligned}\right\} \leftarrow \textbf{3 marks}$$

$$v_2 = \sqrt{1.40^2 + (-1.50)^2} = 2.1 \text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

$$\theta = \tan^{-1}\left(\frac{-1.50}{1.40}\right) = -47^\circ \qquad \leftarrow \textbf{1 mark}$$

3. A uniform 15 kg beam of length 4.0 m is supported against a wall as shown in the diagram. A 25 kg object is suspended 3.0 m from the hinge P.



a) What is the tension in the support cable? **(5 marks)**

$$\Sigma\tau_p = 0 \qquad \leftarrow \textbf{1 mark}$$

$$W_b \cdot 2.0 + W_l \cdot 3.0 - T\sin 35^\circ \cdot 4.0 = 0$$

$$T = \frac{W_b \cdot 2.0 + W_l \cdot 3.0}{\sin 35^\circ \cdot 4.0}$$

$$= \frac{\left(15\ \text{kg} \cdot 9.8\ \text{m/s}^2 \cdot 2.0\ \text{m}\right) + \left(25\ \text{kg} \cdot 9.8\ \text{m/s}^2 \cdot 3.0\ \text{m}\right)}{\sin 35^\circ \cdot 4.0\ \text{m}}$$

$$= \frac{294\ \text{N}\cdot\text{m} + 735\ \text{N}\cdot\text{m}}{2.29\ \text{m}}$$

← **3 marks**

$$= 4.5 \times 10^2\ \text{N} \qquad \leftarrow \textbf{1 mark}$$

b) What is the magnitude of the horizontal component of the reaction force of the wall on the beam at the hinge P? **(2 marks)**

$$\Sigma F_x = 0$$

$$\therefore F_{R_x} = T\cos 35^\circ$$

← **1 mark**

$$= 4.5 \times 10^2\ \text{N} \cdot \cos 35^\circ$$

$$= 3.7 \times 10^2\ \text{N} \qquad \leftarrow \textbf{1 mark}$$

4. The moon Deimos orbits the planet Mars at an orbital radius of 2.34×10^7 m with an orbital period of 1.08×10^5 s. What is the mass of Mars? **(7marks)**

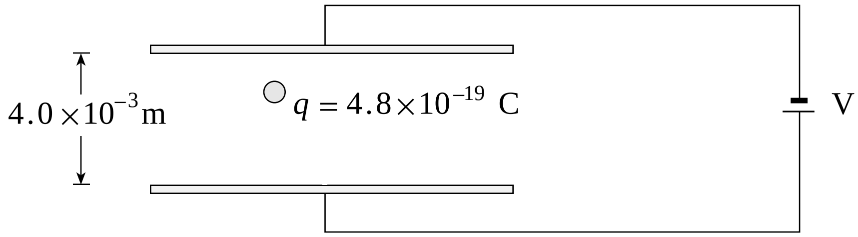
$F_g = F_c$ ← **1 mark**

$\frac{G m_p m_m}{R^2} = \frac{m_m \, 4\pi^2 R}{T^2}$ $(p = \text{planet}, \ m = \text{moon})$ ← **2 marks**

$m_p = \frac{4\pi^2 R^3}{G \, T^2}$ ← **2 marks**

$m_p = 6.50 \times 10^{23}$ kg ← **2 marks**

5. The diagram shows a small sphere of mass 1.5×10^{-14} kg held in equilibrium between two parallel plates by electrostatic and gravitational forces.



If the plates are 4.0×10^{-3} m apart and the sphere carries a charge of magnitude 4.8×10^{-19} C, what is the potential difference V between the plates? **(7marks)**

$F_E = F_g$ ← **2 mark**

$Eq = mg$ ← **2 marks**

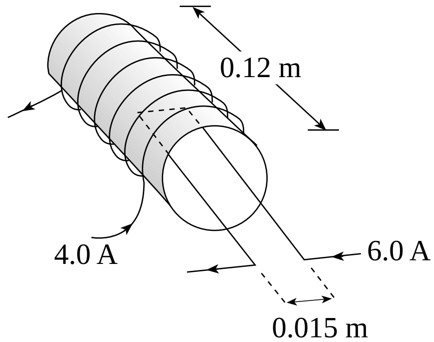
$\frac{Vq}{d} = mg$ ← **1 mark**

$V = \frac{mgd}{q}$

$= \frac{1.5\times10^{-14}\times9.8\times4.0\times10^{-3}}{4.8\times10^{-19}}$ ← **1 mark**

$= 1.2\times10^{3}$ V ← **1 mark**

6. The diagram below shows a 650-turn solenoid carrying a 4.0 A current.



What is the magnitude of the magnetic force on the 0.015 m segment of wire carrying a 6.0 A current inside the solenoid as shown? **(7marks)**

$$B = \mu_0 \frac{N}{l} \cdot I$$ ← **1 mark**

$$= \mu_0 \cdot \frac{650}{0.12\ \text{m}} \cdot 4.0\ \text{A}$$

$$= 0.0272\ \text{T}$$ ← **2 marks**

$$F = B I l$$ ← **1 mark**

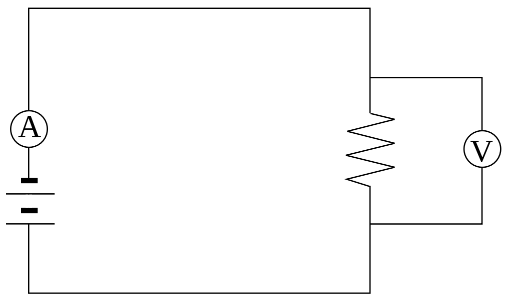
$$= 0.0272\ \text{T} \cdot 6.0\ A \cdot 0.015\ \text{m}$$

$$= 2.4 \times 10^{-3}\ \text{N}$$ ← **3 marks**

7. You are given a voltmeter, an ammeter, connecting wires, a battery, and a resistor of unknown resistance. Describe a method you could use with this apparatus to determine the unknown resistance. (A circuit diagram may be used as **part** of your answer.) **(4 marks)**

Connect the ammeter, battery and resistor in series. Connect the voltmeter in parallel with the unknown resistor. Measure the current through the resistor and the potential difference across the resistor. Using Ohm's law, $V = IR$, you can find the value of the unknown resistor R.

OR



- **Connect circuit as shown.**
- **Measure the current, *I*, and the voltage, *V*.**
- **Calculate *R* from Ohm's Law:** $R = \frac{V}{I}$

PART C: ELECTED TOPICS

SECTION I: Quantum Physics

1. A singly ionized helium atom contains two protons in its nucleus. What is the energy of an electron in the second excited state $(n = 3)$ of this ion? **(3 marks)**

$$E_n = (-13.6\ e\text{V})\frac{Z^2}{n^2} \quad \leftarrow \textbf{1 mark}$$

$$= -13.6 \times \frac{2^2}{3^2} \quad \leftarrow \textbf{1 mark}$$

$$= -6.0\ e\text{V} \quad \leftarrow \textbf{1 mark}$$

2. A laser emits light of wavelength 6.3×10^{-7} m.

a) What is the energy of each photon emitted? **(2marks)**

$$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{630 \times 10^{-9}}$$

$$= 3.2 \times 10^{-19}\ \text{J}$$

b) The total power output of the laser is 0.50 W. How many photons are emitted in a 3.0 s interval? **(2marks)**

$$P = \frac{\Delta E}{t}$$

$$0.50 = \frac{N(3.16 \times 10^{-19})}{3.0}$$

$$N = 4.7 \times 10^{18}\ \text{photons}$$

3. Light of frequency 7.9×10^{14} Hz emits photoelectrons from a metal surface with a maximum speed of 6.7×10^{5} m/s. What frequency of light is necessary to release photoelectrons from this same surface with twice this speed? **(5 marks)**

$$E_k = hf - W$$

$$W = hf - E_k$$

$$= \left(6.63 \times 10^{-34}\right)\left(7.9 \times 10^{14}\right) - \frac{1}{2}\left(9.1 \times 10^{-31}\right)\left(6.7 \times 10^{5}\right)^2$$

$$= 5.24 \times 10^{-19} - 2.04 \times 10^{-19}$$

$$= 3.2 \times 10^{-19} \text{ J} \quad \Big\} \leftarrow \textbf{3 marks}$$

$$hf = E_k + W$$

$$= \frac{1}{2}\left(9.1 \times 10^{-31}\right)\left((2)6.7 \times 10^{5}\right)^2 + 3.2 \times 10^{-19}$$

$$hf = 1.14 \times 10^{-18} \text{ J}$$

$$f = 1.7 \times 10^{15} \text{ Hz} \quad \Big\} \leftarrow \textbf{2 marks}$$

END OF SECTION I: Quantum Mechanics

SECTION II: Fluid Theory

1. A 45 kg ballet dancer briefly balances on her toe. Calculate the pressure applied on the floor by the dancer's toe if the toe has an area of $2.2 \times 10^{-4}\ \text{m}^2$. **(3 marks)**

$F = mg$

$= 441\ \text{N}$ ← **1 mark**

$P = \dfrac{F}{A}$ ← **1 mark**

$= \dfrac{441}{2.2 \times 10^{-4}}$

$= 2.0 \times 10^{6}\ \text{Pa}$ ← **1 mark**

2. The absolute pressure of a gas in a rigid container at $20°\ \text{C}$ is $4.5 \times 10^{5}\ \text{Pa}$. If the temperature increases to $40°\ \text{C}$, what is the pressure of the gas? **(4marks)**

$PV = nRT$

$\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2}$

$V_1 = V_2$

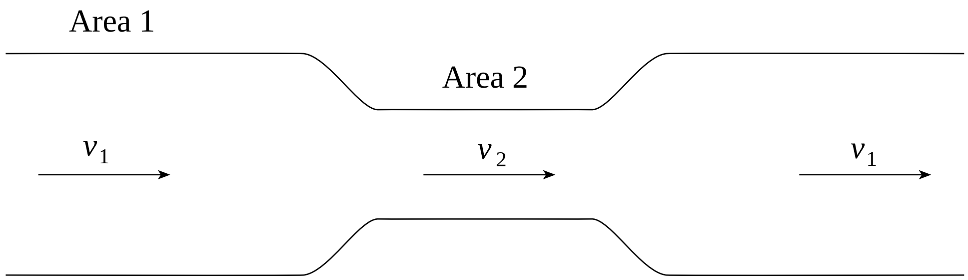
$\dfrac{P_1}{T_1} = \dfrac{P_2}{T_2}$ ← **1 mark**

$T_1 = 20 + 273°\ \text{K}, \quad T_2 = 40 + 273° = 313°\ \text{K}$ ← **1 mark**

$\dfrac{4.5 \times 10^{5}}{293} = \dfrac{P_2}{313}$ ← **1 mark**

$P_2 = 4.8 \times 10^{5}\ Pa$ ← **1 mark**

3. Fresh water flows through the pipe shown below. The pressure in Area 1 is $P_1 = 1.6 \times 10^5$ Pa and in Area 2 is $P_2 = 1.2 \times 10^5$ Pa.



If the speed of the water in Area 1 is $v_1 = 3.0$ m/s, what is the speed of the water v_2 in Area 2?
(5marks)

$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

$$h_1 = h_2$$

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$$

$$P_1 - P_2 + \frac{1}{2}\rho v_1^2 = \frac{1}{2}\rho v_2^2$$ ← **2 marks**

$$1.6 \times 10^5 - 1.2 \times 10^5 + \frac{1}{2}(1\,000)(3.0)^2 = \frac{1}{2}(1\,000)v_2^2$$ ← **2 marks for correct sub for *v*, *P*, ρ**

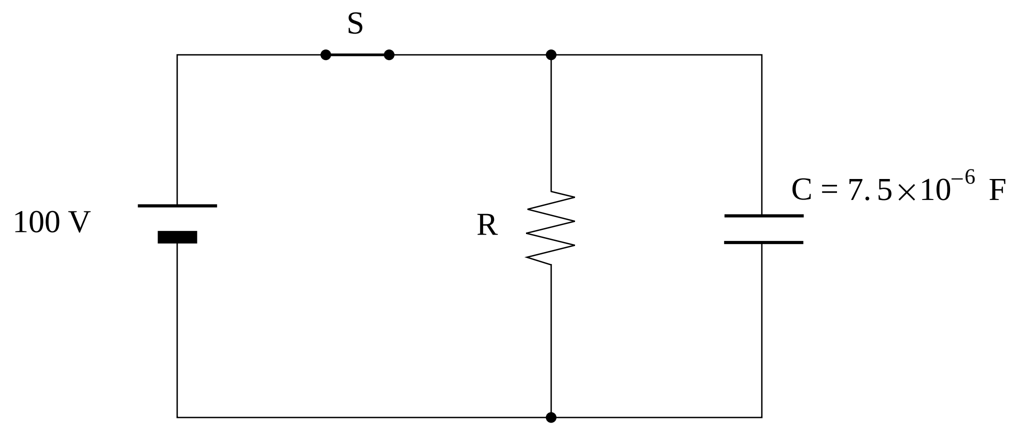
$$4.45 \times 10^4 = \frac{1}{2}(1\,000)v_2^2$$

$$v_2 = 9.4 \text{ m/s}$$ ← **1 mark**

END OF SECTION II: Fluid Theory

SECTION III: AC Circuitry and Electronics

1. The diagram below shows a circuit in which switch S has been closed for a long time. When the switch is opened, it takes 22 s for the voltage across the capacitor to drop to 37 V.



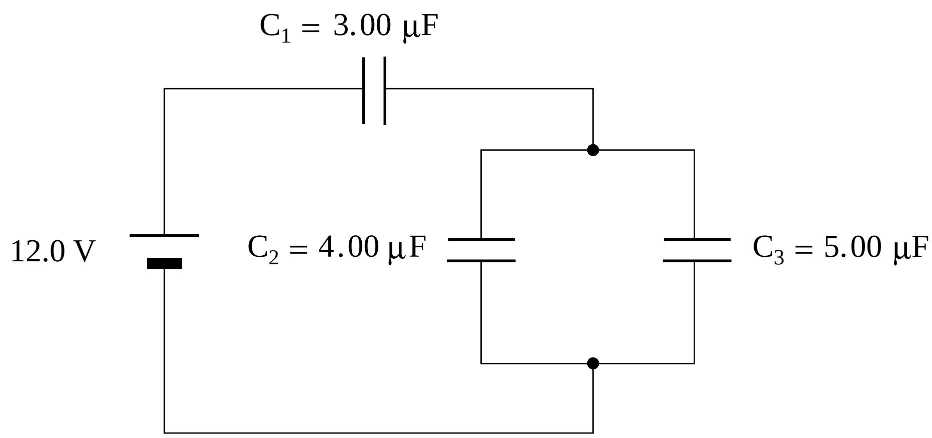
What is the value of resistor R? **(3marks)**

$\tau = RC$ ← **1 mark**

$22 = R\left(7.5\times10^{-6}\right)$ ← **1 mark**

$R = 2.9\times10^{6}\ \Omega$ ← **1 mark**

2. What is the equivalent capacitance of the circuit below? **(4marks)**

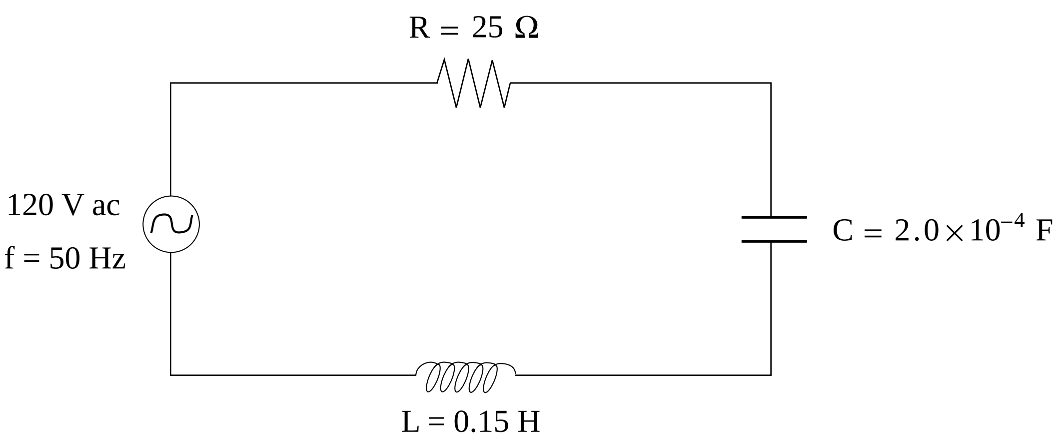


$C_{||} = 4.00\ \mu F + 5.00\ \mu F = 9.00\ \mu F$ ← **2 marks**

$$\frac{1}{C_T} = \frac{1}{3.00\ \mu F} + \frac{1}{9.00\ \mu F}$$

$C_T = 2.25\ \mu F$ ← **2 marks**

3. What is the impedance of the following circuit? **(5marks)**



$$X_L = 2\pi f L = 2\pi(50)(0.15) = 47\ \Omega$$ ← **2 marks**

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(50)\left(2.0\times10^{-4}\right)} = 16\ \Omega$$ ← **2 marks**

$$Z = \sqrt{R^2 + \left(X_L - X_c\right)^2} = \sqrt{25^2 + (47-16)^2} = 40\ \Omega$$ ← **1 mark**

END OF SECTION III: AC Circuitry and Electronics

END OF KEY