Physics 12

June 1996 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 Mechanics
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 C3, 4	16.	K	5	C	2	VI A7
2.	U	1	B	2	I B10	17.	U	5	C	2	VI A2
3.	K	1	C	2	II A4	18.	U	5	B	2	VI B2
4.	U	1	B	2	II B6	19.	U	5	B	2	VI B2, IIA5
5.	H	1	B	2	II A2	20.	K	5	D	2	VII B3
6.	K	2	D	2	III A2	21.	U	5	D	2	VII A6, 7
7.	U	2	B	2	III C7, 8	22.	U	5	A	2	VII A10
8.	H	1	C	2	I A1	23.	U	5	C	2	VII A8, 11
9.	H	2	D	2	III A6, B2	24.	K	6	B	2	VIII A1, 2
10.	U	3	A	2	IV A3	25.	U	6	A	2	VIII A3, 4
11.	U	3	A	2	IV B8	26.	U	6	C	2	VIII A7
12.	K	4	A	2	V B1	27.	U	6	A	2	VIII B1, A3
13.	U	4	A	2	V A6	28.	H	6	A	2	VIII B7, 8
14.	U	4	C	2	V B6	29.	U	6	B	2	VIII B11
15.	U	4	A	2	V B14	30.	U	6	D	2	VIII B13

PART B: Written Response

Q	B	C	T	S	CGR
1.	1	U	1	7	I C 6
2.	2	U	2	7	III D 2
3.	3	U	3	7	IV B 8, II B5
4.	4	H	4	9	II A 5, B 6, V A 3, 4, 6
5.	5	U	5	7	VI B 2, 3
6.	6	U	6	7	VIII A 3, 6
7.	7	H	5	4	VII A 11, 12

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 A6
	2.	9	U	7	4	II A 9, 14
	3.	10	U	7	5	II A 6, 14, B 6

or

	Q	B	C	T	S	CGR
Section II	1.	11	U	8	3	III A 2
	2.	12	U	8	4	III B 7, 4
	3.	13	U	8	5	III A 13

or

	Q	B	C	T	S	CGR
Section III	1.	14	U	9	3	I A 5
	2.	15	U	9	4	I A 7
	3.	16	U	9	5	I C 2

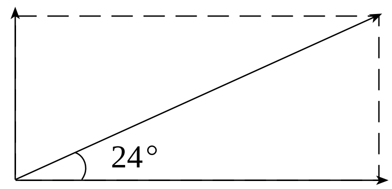
Multiple Choice	=	60 (30 questions)
Written Response	=	60 (10 questions)
Total	**=**	**120 marks**

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

1. A soccer ball is kicked over level ground with an initial velocity of 18 m/s, 24° above the horizontal.

   a) How long does it take the ball to return to the ground? **(4 marks)**

$$v_V = 18\sin 24^\circ = 7.3\ \text{m/s}$$



← **1 mark**

$$v_H = 18\cos 24^\circ = 16.4\ \text{m/s}$$

Vertical components: $v_0 = 7.3$ m/s

$+\uparrow$ $a = -9.8$ m/s^2 ← **1 mark**

$d = 0$ m

$$d = v_0 t + \frac{1}{2}at^2$$

$0 = 7.3t - 4.9t^2$ ← **1 mark**

$0 = t(7.3 - 4.9t)$

~~$t = 0$~~ s or $t = 1.49$ s ← **1 mark**

OR

$v_F = v_0 + at$

$0 = 7.3 - 9.8t$ ← **1 mark**

$t = 0.747$ ← **1 mark**

$t_{TOT} = t_{up} + t_{dwn}$

$t = 1.49$ s ← **1 mark**

   b) What is the range of the ball? **(3 marks)**

$$v_H = 18\cos 24^\circ = 16.4\ \text{m/s}$$

Horizontal components: $v = 16.4$ m / s ← **1 mark**

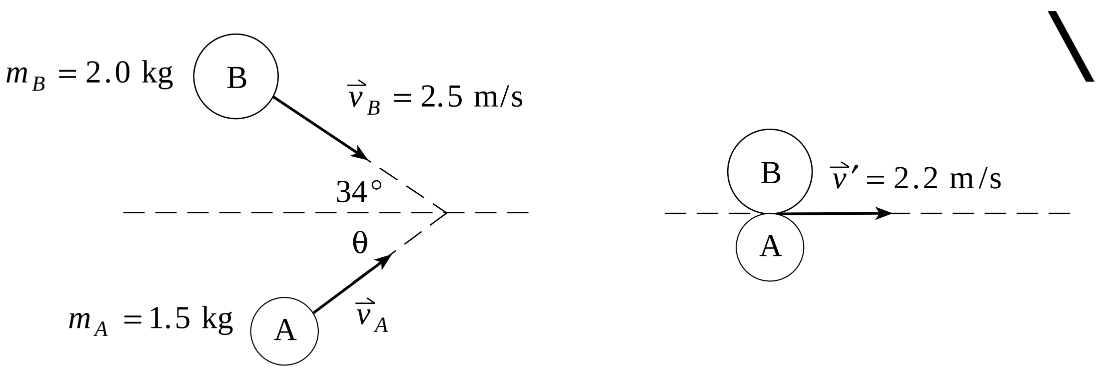
$t = 1.49$ s

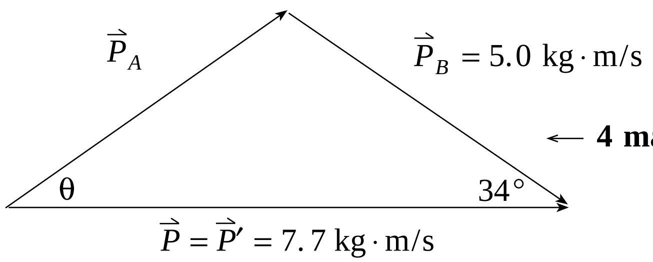
$d = vt = 16.4 \times 1.49$ ← **1 mark**

$d = 25$ m ← **1 mark**

No marks given or subtracted for vertical work.

2. Two air pucks approach each other, stick together and then travel due east as shown below. Find the initial velocity (magnitude and direction) of puck **A**. **(7 marks)**





← **4 marks**

- Momentum is conserved. ← **1 mark**
- Momentum is a vector. ← **1 mark**
- Calculating P_B and P'. ← **1 mark**
- Correct triangle. ← **1 mark**

$P_A{}^2 = 7.7^2 + 5.0^2 - 2(7.7)(5.0)\cos 34°$ ← **1 mark**

$P_A = 4.52$ kg · m/s ← **½ mark**

$v_A = \frac{4.52}{1.5} = 3.0$ m/s ← **½ mark**

$\frac{\sin\theta}{5.0} = \frac{\sin 34°}{4.52}$ ← **½ mark**

$\theta = 38°$ ← **½ mark**

or 38° N of E

Alternate Solution:

$$4.145 \text{ kgm/s} + P_{Ax} = 7.7 \text{ kgm/s}$$ ← **2 marks**

$$P_{Ax} = 3.56 \text{ kgm/s}$$ ← **½ mark**

$$-2.80 + P_{Ay} = 0$$ ← **2 marks**

$$P_{Ay} = 2.80 \text{ kgm/s}$$ ← **½ mark**

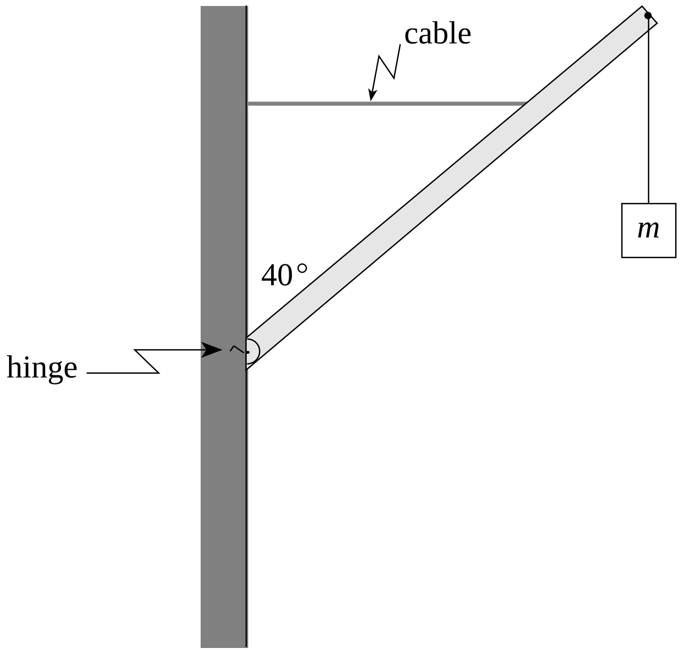
$$P_A = 4.52 \text{ kgm/s}$$ ← **½ mark**

$$v_A = 3.0 \text{ m/s}$$ ← **½ mark**

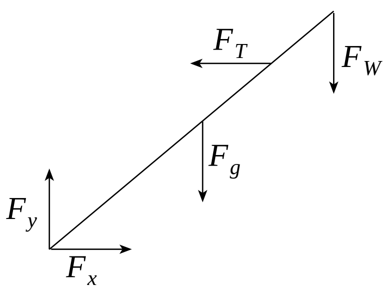
$$\tan\theta = \frac{2.80}{3.56}$$ ← **½ mark**

$$\theta = 38^\circ$$ ← **½ mark**

3. A uniform 350 kg beam of length 4.2 m is held stationary by a horizontal cable. The cable is attached to a point on the beam 3.0 m from the hinge.



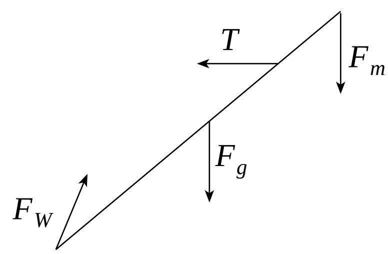
a) Draw and label a free body diagram showing the forces on the beam. **(2 marks)**



OR

Either diagram for

2 marks



b) If the maximum tension the cable can withstand is 1.3×10^4 N, what maximum mass, ***m***, can be suspended from the end of the beam? **(5 marks)**

$$\tau_{cw} = \tau_{ccw} \qquad \leftarrow \textbf{ 1 mark}$$

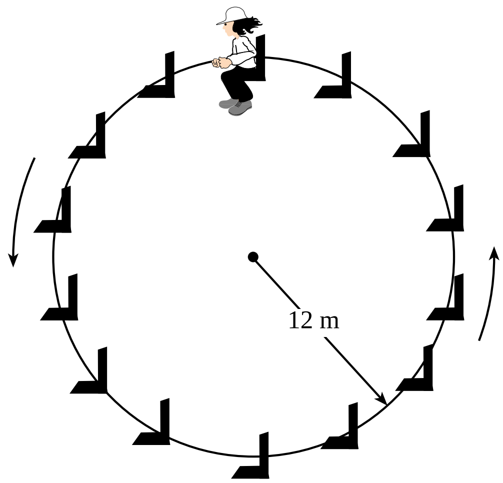
$$F_g(\cos 50)(2.1) + F_W(\cos 50)(4.2) = (1.3\times10^4)(\sin 50)(3.0)$$

$$4\ 630 + F_W(\cos 50)(4.2) = 2.99\times10^4 \qquad \leftarrow \textbf{ 2 marks}$$

$$F_W = 9.35\times10^3 \text{ N} \qquad \leftarrow \textbf{ 1 mark}$$

$$m = \frac{F_W}{g} = 950 \text{ kg} \qquad \leftarrow \textbf{ 1 mark}$$

4. A 35 kg child rides a ferris wheel of radius 12 m. The child moves in a vertical circle at a constant speed and completes one rotation every 9.0 s.



a) As the child travels over the top, what is the magnitude of the force that the seat exerts on the child? **(5 marks)**

$$F_{\text{net}} = F_g - F_N$$

$$F_c = F_g - F_N \qquad \leftarrow \textbf{2 marks}$$

$$F_N = F_g - F_c$$

$$= mg - \frac{m4\pi^2 r}{T^2}$$

$$= (35)(9.8) - \frac{(35)\left(4\pi^2\right)(12)}{(9.0)^2} \qquad \leftarrow \textbf{2 marks}$$

$$= 343 - 205$$

$$F_N = 138\ \text{N} \qquad \leftarrow \textbf{1 mark}$$

b) How does the magnitude of the child's acceleration at the top of the ride compare to her acceleration at the bottom?

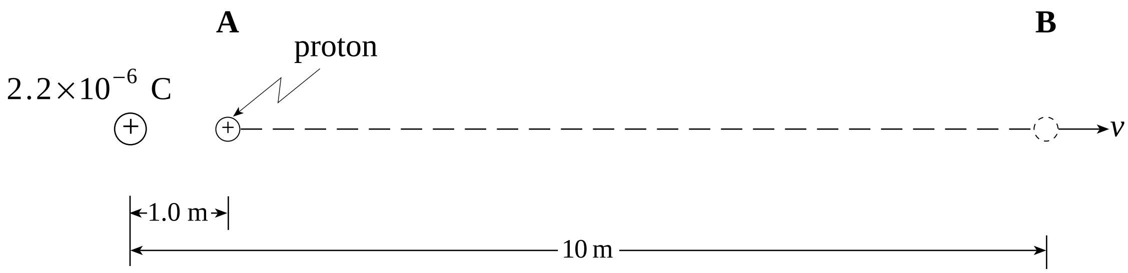
The child's acceleration at the top is: (circle one) **(1 mark)**

i) less than at the bottom.
ii) greater than at the bottom.
iii) the same as at the bottom.

Explain your choice using principles of physics. **(3 marks)**

Since this child is moving in uniform circular motion her net force must be a constant centripetal force. The magnitude of the acceleration must therefore be constant.

5. A proton is located at **A,** 1.0 m from a fixed $+2.2\times10^{-6}$C charge.



a) What is the change in potential energy of the proton as it moves to **B**, 10 m from the fixed charge? **(5 marks)**

$$\Delta E_p = \frac{kqQ}{r_2} - \frac{kqQ}{r_1}$$ ← **2 marks**

$$\Delta E_p = \left(\frac{9\times10^9\left(1.6\times10^{-19}\right)\left(2.2\times10^{-6}\right)}{10}\right) - \left(\frac{9\times10^9\left(1.6\times10^{-19}\right)\left(2.2\times10^{-6}\right)}{1.0}\right)$$ ← **2 marks**

$$\Delta E_p = -2.9\times10^{-15}\text{ J}$$ ← **1 mark**

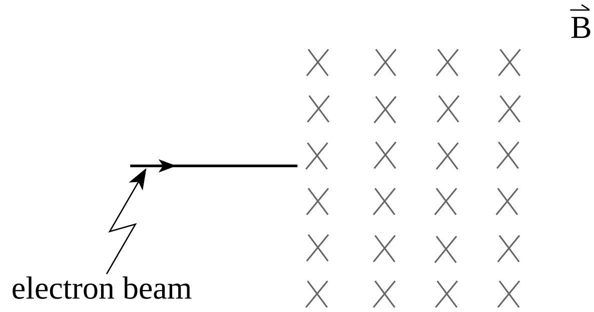
b) If the proton started from rest at **A**, what would be its speed at **B**? **(2 marks)**

$$\Delta E_p = E_k = \frac{1}{2}mv^2$$ ← **1 mark**

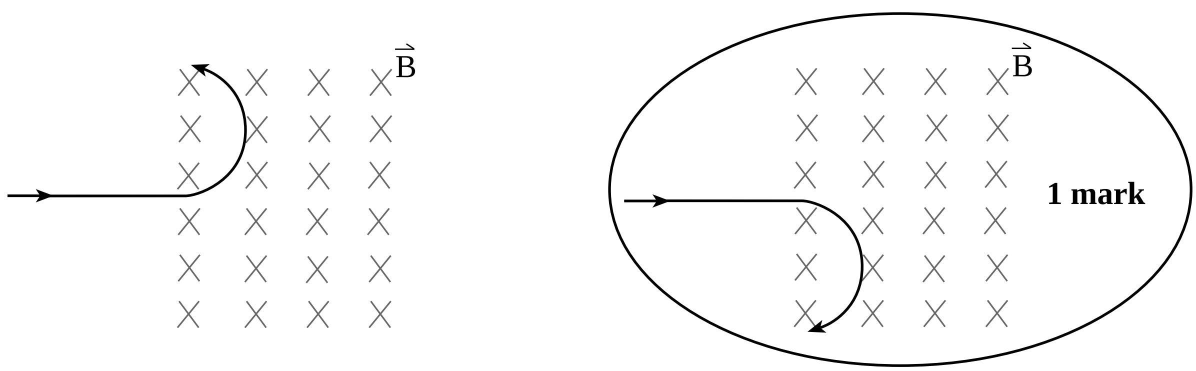
$$2.9\times10^{-15} = \frac{1}{2}\left(1.67\times10^{-27}\right)v^2$$ ← **½ mark**

$$v = 1.9\times10^6\text{ m/s}$$ ← **½ mark**

6. A beam of electrons travelling at 1.8×10^8 m/s is directed towards a 0.014 T magnetic field as shown in the diagram below.



a) Which of the following diagrams illustrates the path of the electron beam once in the magnetic field? (Circle one.) **(1 mark)**



b) What is the radius of the path of the electron beam while in the magnetic field? **(6 marks)**

$$\left.\begin{aligned} F_B &= F_C \\ QvB &= \frac{mv^2}{r} \end{aligned}\right\} \leftarrow \textbf{3 marks}$$

$$r = \frac{mv}{BQ} \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{9.11\times10^{-31}\ \text{kg}\times\left(1.8\times10^{8}\ \text{m/s}\right)}{0.014\ \text{T}\times1.6\times10^{-19}\ \text{C}} \qquad \leftarrow \textbf{1 mark}$$

$$= 0.073\ \text{m} \qquad \leftarrow \textbf{1 mark}$$

7. Electrical power is transmitted over large distances at very high voltages. Using principles of physics, explain how high voltages reduce power losses in transmission lines. **(4 marks)**

When power is transmitted at high voltage, the current is relatively low, $(P = VI)$.
As power loss in a conductor is given by $P = I^2R$, where R is constant, the lower current causes a lower power loss as heat.

PART C: ELECTED TOPICS

SECTION I: Quantum Mechanics

1.	What is the energy of a photon of light of wavelength 550 nm?	**(3 marks)**

$E = hf$ ← $\frac{1}{2}$ **mark**

$E = h\frac{c}{\lambda}$ ← $\frac{1}{2}$ **mark**

$c = f\lambda$ ← $\frac{1}{2}$ **mark**

$$= \frac{6.63\times10^{-34}\left(3.0\times10^{8}\right)}{550\times10^{-9}}$$

$$E = 3.6\times10^{-19}\ \text{J}$$

← $1\frac{1}{2}$ **mark**

2.	The work function for a metal is 1.65 eV. If the incident light has a wavelength of 410 nm, what would be the maximum speed of the emitted photoelectrons at the metal's surface?	**(4 marks)**

$E_{K_{\text{max}}} = h\frac{c}{\lambda} - W_0$ ← **1 mark**

$$= \frac{4.14\times10^{-15}\times3.00\times10^{8}}{4.10\times10^{-7}} - 1.65$$

$$= 3.03 - 1.65$$

$= 1.38\ e\text{V}$ ← **1 mark**

$= 2.21\times10^{-19}\ \text{J} = \frac{1}{2}mv^2$ ← **1 mark**

$$v^2 = \frac{2\left(2.2\times10^{-19}\right)}{9.11\times10^{-31}}$$

$v = 6.97\times10^{5}\ \text{m/s}$ ← **1 mark**

3. What is the momentum of the photon emitted when the electron in a hydrogen atom changes from the $n = 4$ to $n = 1$ state? **(5 marks)**

$$\Delta E = \frac{hc}{\lambda}$$

$$E_4 - E_1 = \frac{hc}{\lambda}$$

$$\frac{-13.6}{4^2} - \frac{-13.6}{1^2} = \frac{1.242 \times 10^{-6}}{\lambda}$$

$$\lambda = 9.74 \times 10^{-8}$$

3 marks

$$p = \frac{h}{\lambda}$$

$$= \frac{6.63 \times 10^{-34}}{9.74 \times 10^{-8}}$$

$$p = 6.8 \times 10^{-27} \text{ kg} \cdot \text{m/s}$$

2 marks

END OF SECTION I: Quantum Mechanics

SECTION II: Fluid Theory

1. A solid uniform cube of unknown material is $0.13\ \text{m}$ on a side and has a mass of $2.0\ \text{kg}$. What is the density of this cube? **(3 marks)**

$$\rho = \frac{m}{V} \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{2.0}{(0.13)^3} \qquad \leftarrow \textbf{1 mark}$$

$$= 910\ \text{kg/m}^3 \qquad \leftarrow \textbf{1 mark}$$

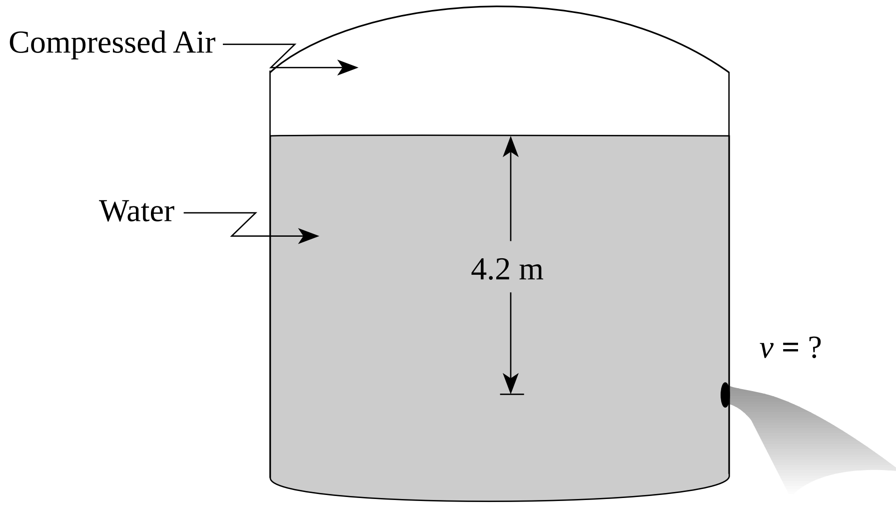
2. A rigid sealed container is filled with a gas. Initially the gas is at a temperature of 28°C and at a pressure of $4.0\times10^5\ \text{Pa}$. If the gas is then heated to a temperature of 52°C, what is the new pressure in the container? **(4 marks)**

$$\left.\begin{array}{l} \dfrac{P_1V_1}{T_1} = \dfrac{P_2V_2}{T_2} \\ \textbf{OR} \\ \dfrac{P_1}{T_1} = \dfrac{P_2}{T_2} \end{array}\right\} \leftarrow \textbf{2 marks}$$

$$\frac{4.0\times10^5}{301} = \frac{P_2}{325} \qquad \leftarrow \textbf{1 mark}$$

$$P_2 = 4.3\times10^5\ \text{Pa} \qquad \leftarrow \textbf{1 mark}$$

3. The pressure of the compressed air inside the tank shown below is 1.5×10^4 Pa greater than the outside air pressure. There is a small hole in the side of the tank, 4.2 m below water level.



What is the speed of the water leaving this hole? **(5 marks)**

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

$$v_1 = 0;\ \ h_1-h_2 = 4.2\ \text{m}$$
$$P_1-P_2 = 1.5\times10^4\ \text{Pa}$$
} **2 marks**

$$\left(P_1-P_2\right)+\rho g\left(h_1-h_2\right)=\frac{1}{2}\rho v_2{}^2$$

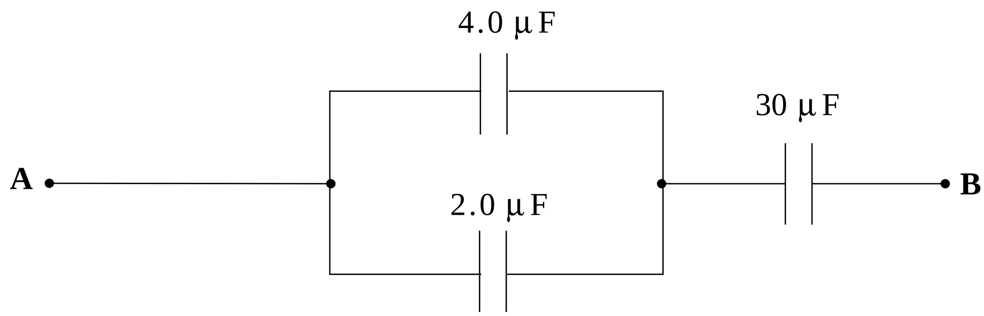
$$1.5\times10^4+(1\,000)(9.8)(4.2)=\frac{1}{2}(1\,000)v_2{}^2$$ ← **1 mark**

$$v_2 = 10.6\ \text{m/s}$$ ← **1 mark**

END OF SECTION II: Fluid Theory

SECTION III: AC Circuitry and Electronics

1. What is the total capacitance between points **A** and **B** in the diagram below? **(3 marks)**

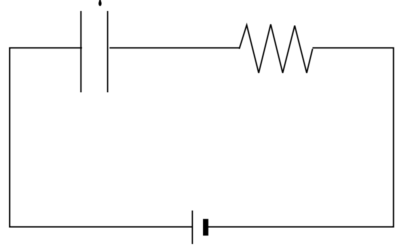


$C_{||} = 4.0 + 2.0 = 6.0\ \mu\text{F}$ ← **1 mark**

$\dfrac{1}{C_T} = \dfrac{1}{6.0\ \mu\text{F}} + \dfrac{1}{30\ \mu\text{F}}$ ← **1 mark**

$C_T = 5.0\ \mu\text{F}$ ← **1 mark**

2. What is the time constant for the circuit shown below? **(2 marks)**

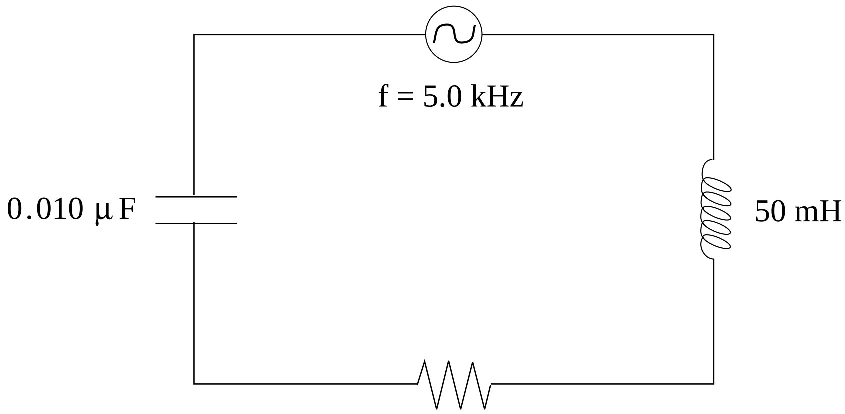


$$\left.\begin{aligned}\tau &= RC \\ &= \left(1.5\times10^{-6}\ \mathrm{F}\right)\left(2.0\times10^{6}\ \Omega\right) \\ &= 3.0\ \mathrm{s}\end{aligned}\right\}\ \textbf{2 marks}$$

b) What is the voltage across the capacitor when the battery has been connected for one time constant? **(2 marks)**

$$\left.\begin{aligned}V &= \mathcal{E}(0.63) \\ V &= (24)(0.63) \\ &= 15\ \mathrm{V}\end{aligned}\right\}\ \textbf{2 marks}$$

3. What is the impedance of the LCR circuit shown below? **(5 marks)**



$$\left.\begin{aligned} X_L &= 2\pi f L \\ &= 1\ 570\ \Omega \\ X_C &= \frac{1}{2\pi f C} \\ &= 3\ 185\ \Omega \end{aligned}\right\}$$ **3 marks**

$$Z = \left(R^2 + \left(X_L - X_C\right)^2\right)^{\frac{1}{2}}$$

$$= 2\ 200\ \Omega \qquad (2.2\ \text{k}\Omega)$$ ← **2 marks**

END OF SECTION III: AC Circuitry and Electronics

END OF KEY