JUNE 1995 PHYSICS 12 PROVINCIAL EXAMINATION
ANSWER KEY / 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 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	II A2, II B6	16.	U	5	B	2	VI B2
2.	U	1	A	2	I B1, III A2	17.	U	5	B	2	VI B2
3.	U	1	B	2	I A1	18.	K	5	B	2	VII A1, 3
4.	K	2	A	2	III C1	19.	U	5	B	2	VII A6, 8
5.	U	2	B	2	III C2, III C11	20.	U	5	C	2	VII A10
6.	H	2	B	2	III C9, 8	21.	U	5	A	2	VII A11
7.	U	3	D	2	IV A3	22.	K	6	A	2	VIII A2
8.	H	3	A	2	IV B8	23.	U	6	C	2	VIII A6
9.	K	4	B	2	V A5	24.	U	6	D	2	VIII A10
10.	U	4	D	2	V B3	25.	K	6	D	2	VIII B5, 6
11.	U	4	A	2	V B5	26.	U	6	B	2	VIII B13
12.	U	4	B	2	V B15	27.	U	6	C	2	VIII A7
13.	H	4	C	2	V B12	28.	U	6	C	2	VIII B10
14.	K	5	C	2	VI A7	29.	U	6	D	2	VIII B5
15.	U	5	D	2	VI A3	30.	H	6	C	2	VIII B7

PART B: WRITTEN-RESPONSE

Q	B	C	T	S	CGR
1.	1	U	1	7	II B6, 5
2.	2	U	2	7	III D2
3.	3	U	3	7	IV B 8
4.	4	U	4	7	V A4, II B1
5.	5	U/H	5	9	VI B2
6.	6	U	6	7	VIII A5, 9
7.	7	H	1	4	I C2, 4

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 A14
	2.	9	U	7	4	II A9, C9
	3.	10	U	7	5	II B6, A4

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 A9

or

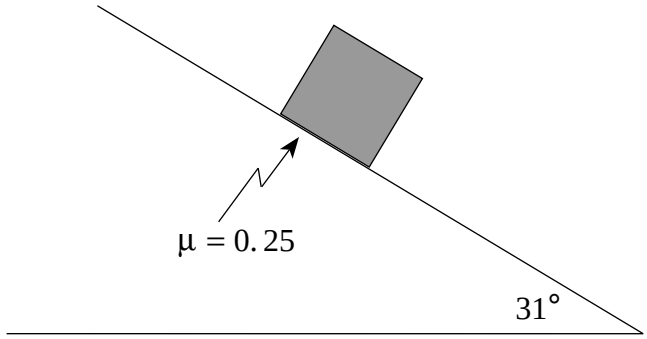
	Q	B	C	T	S	CGR
Section III	1.	14	U	9	3	I E5
	2.	15	U	9	4	I A5
	3.	16	U	9	5	I C2, B3, A10

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

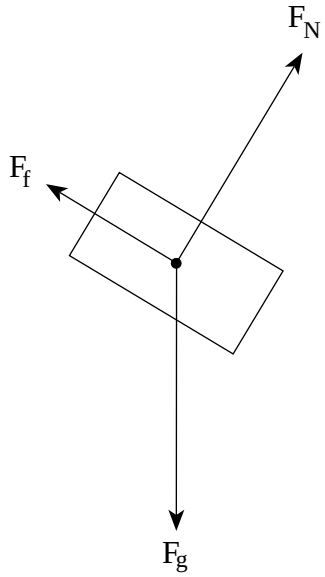
LEGEND:

Q = Question
K = Keyed response
B = Score Box Number
C = Cognitive level
S = Score
T = Topic
CGR = Curriculum Guide Reference

1. An 87 kg block slides down a 31° slope as shown in the diagram below. The coefficient of friction between the block and the surface is 0.25. **(7 marks)**



What is the acceleration of the block?



$$F_{net} = ma$$

$$F_{g_{\parallel}} - F_F = ma \qquad \textbf{3 marks}$$

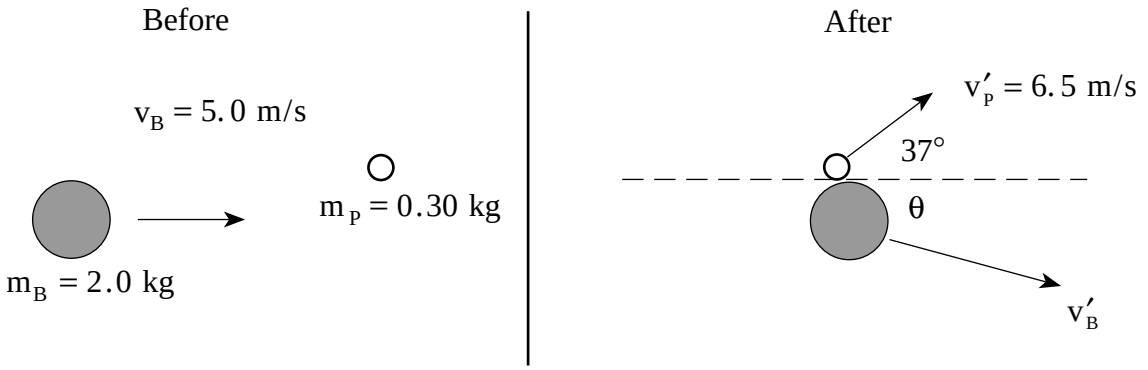
$$mg\sin\theta - \mu mg\cos\theta = ma$$

$$a = g\sin\theta - \mu g\cos\theta \qquad \textbf{2 marks}$$

$$= \left(9.8\ \text{m/s}^2\right)(\sin 31°) - (0.25)\left(9.8\ \text{m/s}^2\right)(\cos 31°) \qquad \textbf{2 marks}$$

$$= 2.9\ \text{m/s}^2$$

2. A 2.0 kg bowling ball travelling 5.0 m/s collides with a stationary 0.30 kg bowling pin. After the collision, the pin moves at a speed of 6.5 m/s in the direction shown in the diagram. What is the velocity (magnitude and direction) of the bowling ball after the collision? **(7 marks)**

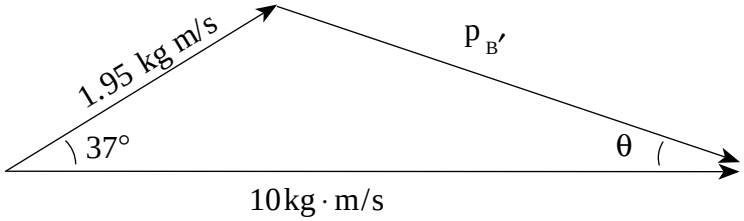


$p_B = (2.0)(5.0)$

$= 10 \text{ kg}\cdot\text{m/s}$ **1 mark**

$p'_p = (0.30)(6.5)$

$= 1.95 \text{ kg}\cdot\text{m/s}$ **1 mark**



1 mark for diagram

$p'^2_B = (10)^2 + (1.95)^2 - (2)(10)(1.95)\cos 37$

$= 72.66$

$\therefore p'_B = 8.52 \text{ kg}\cdot\text{m/s}$ **2 marks**

$\therefore v'_B = \dfrac{8.52 \text{ kg}\cdot\text{m/s}}{2.0 \text{ kg}}$

$= 4.26$ m/s

$= 4.3$ m/s **1 mark**

$\dfrac{\sin\theta}{1.95} = \dfrac{\sin 37}{8.52}$

$\theta = 7.9°$ **1 mark**

Component Solution

Before		After	
x	***y***	***x***	***y***
$p_x = 2 \times 5 = 10$ **1 mark**	0	$p_{Px} = .3 \times 6.5 \times \cos 37$ $= 1.557$ **1 mark** $\therefore p_{Bx} = 10 - 1.557$ $= 8.443$ **1 mark**	$p_{Py} = .3 \times 6.5 \times \sin 37$ $= 1.174$ $\therefore p_{By} = 1.174$ (down) **1 mark**

$$\therefore p_B{}^2 = (8.443)^2 + (1.174)^2$$

$$p_B = 8.52 \quad \textbf{1 mark}$$

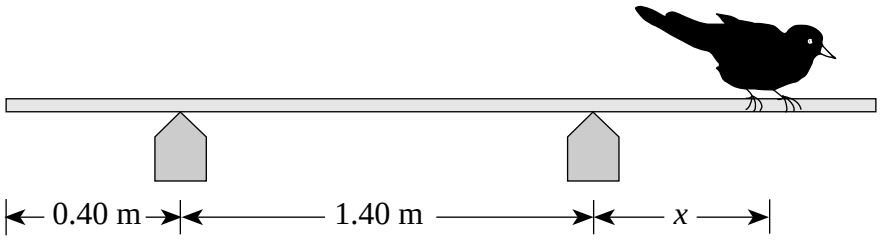
$$\tan\theta = \frac{1.174}{8.443}$$

$$\theta = 7.92^\circ \quad \textbf{1 mark}$$

$$v_B = \frac{p_B}{m_B}$$

$$= 4.26 \quad \textbf{1 mark}$$

3. A 0.75 kg board of length 2.60 m initially rests on two supports as shown.



a) What maximum distance, x, from the right-hand support can a 1.20 kg bird walk before the board begins to leave the left-hand support? **(5 marks)**

Take torques about right support

$$\tau_C = \tau_{CC} \qquad \leftarrow \textbf{ 1 mark}$$

$$1.20(9.8)\,x = 0.75(9.8)\,\underbrace{(0.50)}_{\textbf{1 mark}} \qquad \leftarrow \textbf{ 2 mark}\text{s}$$

$$x = 0.31 \text{ m} \qquad \leftarrow \textbf{ 1 mark}$$

b) What force does the right-hand support exert on the board at that instant? **(2 marks)**

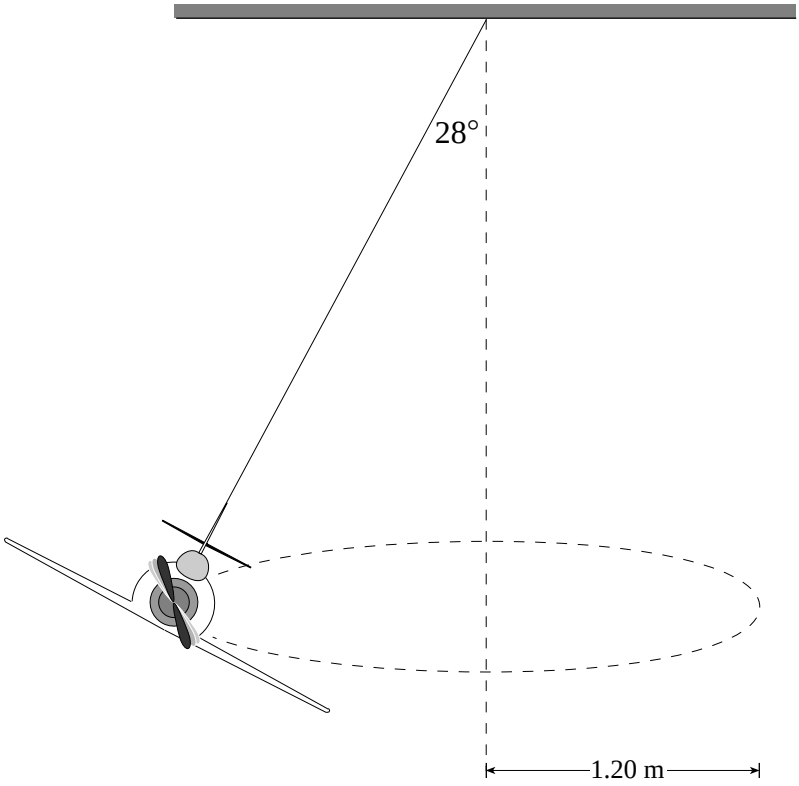
$$F_{up} = F_{down} \qquad \tfrac{1}{2} \textbf{ mark}$$

$$F = 1.2(9.8) + 0.75(9.8) \qquad \tfrac{1}{2} \textbf{ mark}$$

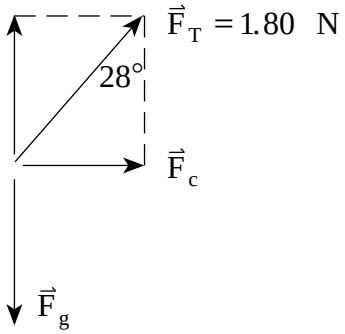
$$F = 11.76 + 7.35 \qquad \tfrac{1}{2} \textbf{ mark}$$

$$= 19 \text{ N} \qquad \tfrac{1}{2} \textbf{ mark}$$

4. The diagram shows a toy plane flying in a circle of radius 1.20 m, supported by a string which makes an angle of 28° with the vertical. The tension in the string is 1.80 N.



a) What is the mass of the plane? **(3 marks)**



$F_g = F_T \cos 28°$

$= 1.59$ N $\leftarrow$ **2 marks**

$m = \frac{1.59}{9.8} = 0.16$ kg $\leftarrow$ **1 mark**

b) How long does the plane take to complete one orbit? **(4 marks)**

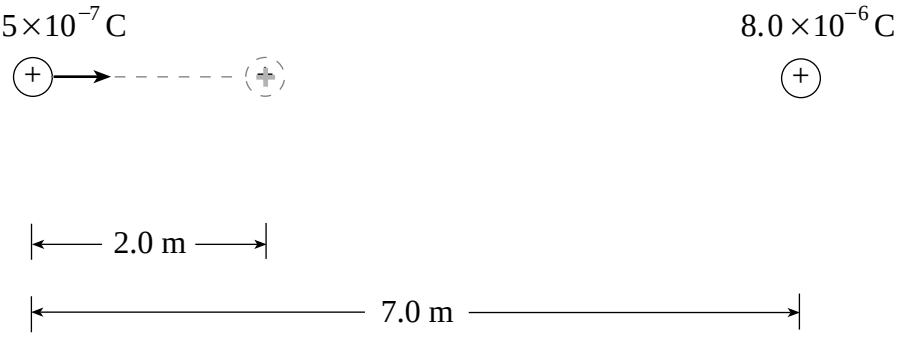
$$F_C = F_T \sin 28°$$

$$= 0.845 \text{ N} \quad \leftarrow \textbf{2 marks}$$

$$\frac{m 4\pi^2 r}{T^2} = 0.845$$

$$T = \sqrt{\frac{0.16 \times 4\pi^2 \times 1.20}{0.845}} = 3.00 \text{ s} \quad \leftarrow \textbf{2 marks}$$

5. a) A $2.5\times10^{-7}\,C$ charge is initially located $7.0\ m$ from a fixed $8.0\times10^{-6}\,C$ charge. What is the minimum amount of work required to move the $2.5\times10^{-7}\,C$ charge $2.0\ m$ closer as shown?



$W = \Delta E_p$ **2 marks** **OR** $= q\Delta V$

$W = \dfrac{kQQ}{5} - \dfrac{kQQ}{7}$ **1 mark** $= q\left(\dfrac{kQ}{r_2} - \dfrac{kQ}{r_1}\right)$

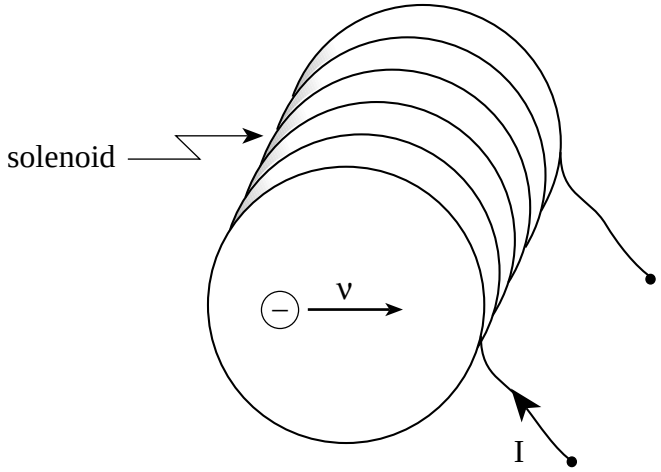
$= .0036 - .0026$ **1 mark** $= 2.5\times10^{-7}\left(\dfrac{kQ}{5} - \dfrac{kQ}{7}\right)$

$W = 1.0\times10^{-3}\,J$ **1 mark** $= 1.0\times10^{-3}\,J$

(b) If the $2.5\times10^{-7}\,C$ charge is moved a further $2.0\ m$ closer to the $8.0\times10^{-6}\,C$ charge, will the additional work required be less than, the same as or greater than the work required in (a)? Using principles of physics, explain your answer. **(4 marks)**

The work required will be greater than in (a). The force acting on the $2.5\times10^{-7}\,C$ charge is greater, therefore the work required to move the same distance will also be greater.

6. A 0.400 m long solenoid has 6 720 turns of wire. A current of 14.5 A flows in the solenoid. An electron inside the solenoid travels perpendicular to the axis of the solenoid with a speed of 6.50×10^5 m/s . What is the magnitude of the magnetic force acting on the electron? **(7 marks)**



$F = Bqv$ **2 marks**

$= \left(\mu_0 \frac{N}{l} I\right) qv$ **2 marks**

$= \left(4\pi \times 10^{-7}\right)\left(\frac{6\ 720}{0.400}\right)(14.5)\left(1.6 \times 10^{-19}\right)\left(6.50 \times 10^5\right)$ **2 marks**

$F = 3.2 \times 10^{-14}$ N **1 mark**

OR

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

$= \left(4\pi \times 10^{-7}\right)\left(\frac{6\ 720}{0.400}\right)(14.5)$ **2 marks**

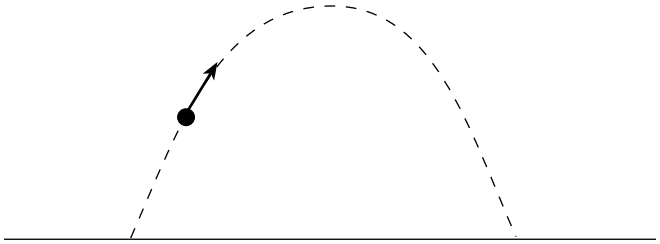
$= 0.306$ T **1 mark**

$F = qvB$ **1 mark**

$= \left(1.6 \times 10^{-19}\right)\left(6.50 \times 10^5\right)(0.306)$ **1 mark**

$F = 3.18 \times 10^{-14}$ N **1 mark**

7. The diagram below shows projectile motion in the absence of friction.



This motion can be analyzed in terms of horizontal and vertical velocity components. Explain the behavior of these velocity components, using principles of physics . **(4 marks)**

- The horizontal velocity component is constant. **1 mark**
- The vertical velocity component constantly changes. **1 mark**
- This vertical acceleration is caused by the force of gravity. **1 mark**
- The downward direction of the change in velocity / acceleration / force must be mentioned. **1 mark**

PART C: ELECTED TOPICS

SECTION I: Quantum Mechanics

1. What is the de Broglie wavelength of a 0.16 kg hockey puck shot by Pavel Bure at 42 m/s?
(3 marks)

$$\lambda = \frac{h}{mv}$$ **1 mark**

$$= \frac{6.626\times10^{-34}}{(0.16)(42)}$$ **1 mark** for correct "h"
$\frac{1}{2}$ **mark** for substitution

$$= 9.9\times10^{-35}\,\text{m}$$ $\frac{1}{2}$ **mark**

2. A metal surface has a work function of 3.43 eV. If electromagnetic radiation with a wavelength of 277 nm strikes the surface and ejects electrons, what is the maximum speed of the ejected electrons?
(4 marks)

$$\left.\begin{aligned} E_k &= \frac{hc}{\lambda} - W_0 \\ \frac{1}{2}mv^2 &= \frac{hc}{\lambda} - W_0 \end{aligned}\right\}$$ **1 mark**

$$= \frac{\left(6.626\times10^{-34}\right)\left(3.0\times10^{8}\right)}{277\times10^{-9}} - (3.43)\left(1.6\times10^{-19}\right)$$

$$E_k = 1.7\times10^{-19}\,\text{J}$$ **1 $\frac{1}{2}$ marks**

$$\left.\begin{aligned} E_k &= \frac{1}{2}mv^2 \\ 1.7\times10^{-19} &= \frac{1}{2}\left(9.1\times10^{-31}\right)v^2 \\ v &= 6.1\times10^{5}\,\text{m/s} \end{aligned}\right\}$$ **1 $\frac{1}{2}$ marks**

3. A electron of a hydrogen atom makes a transition from the fifth excited state (n = 6) to the first excited state (n = 2). What is the wavelength of the emitted photon? **(5 marks)**

$$E_6 = \frac{-13.6\left(1^2\right)}{6^2} = -0.378\ eV \qquad \textbf{1 mark}$$

$$E_2 = \frac{-13.6\left(1^2\right)}{2^2} = -3.4\ eV \qquad \textbf{1 mark}$$

$$\Delta E = -0.378 - (-3.4) \qquad \tfrac{1}{2}\ \textbf{mark}$$

$$= 3.02\ eV$$

$$E = \frac{hc}{\lambda} \qquad \textbf{1 mark}$$

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

$$= \frac{\left(4.14\times10^{-15}\right)\left(3\times10^{8}\right)}{3.02} \qquad \textbf{1 mark} \text{ for correct "h"}$$

$$\lambda = 411\ nm \qquad \tfrac{1}{2}\ \textbf{mark}$$

END OF SECTION I: Quantum Mechanics

SECTION II: Fluid Theory

1. The blade of Pavel Bure's skate exerts a force of $340\ \text{N}$ on a $5.0\times10^{-4}\ \text{m}^2$ section of the ice surface. What pressure does this blade exert on the ice? **(3 marks)**

$$P = \frac{F}{A} \qquad \textbf{2 marks}$$

$$= \frac{340}{5.0\times10^{-4}} \qquad \textbf{1 mark}$$

$$= 6.8\times10^{5}\ \text{Pa}$$

2. Gas inside a rigid sealed container is initially at a pressure of $1.01\times10^{5}\ \text{Pa}$ and a temperature of 25°C. If the gas is cooled to -35°C, what is the new pressure of the gas? **(4 marks)**

$$\left.\begin{aligned} \frac{P_1V_1}{T_1} &= \frac{P_2V_2}{T_2} \quad V_1 = V_2 \\ \therefore \frac{P_1}{T_1} &= \frac{P_2}{T_2} \end{aligned}\right\} \quad \textbf{2 marks}$$

$$\left.\begin{aligned} \frac{1.01\times10^{5}}{298} &= \frac{P_2}{238} \\ P_2 &= 8.07\times10^{4}\ \text{Pa} \end{aligned}\right\} \quad \textbf{2 marks}$$

3. A small 180 kg boat has a volume of $2.1\ \text{m}^3$. How much mass could this boat hold before sinking in fresh water? **(5 marks)**

$$F_B = W_B + W_M \qquad \textbf{2 marks}$$

$$\rho Vg = m_B g + mg$$

$$2.06\times10^{4} = 1.76\times10^{3} + mg \qquad \textbf{2 marks}$$

$$1.88\times10^{4} = mg$$

$$m = 1.9\times10^{3}\ \text{kg} \qquad \textbf{1 mark}$$

END OF SECTION II: Fluid Theory

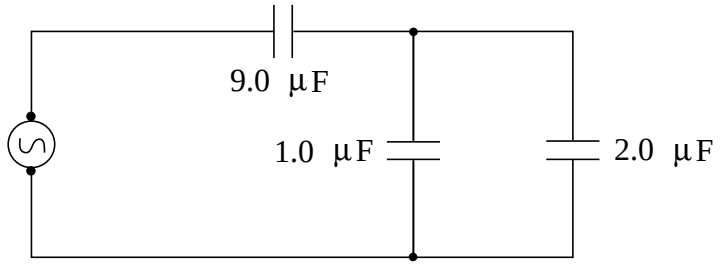
SECTION III: AC Circuitry and Electronics

1. In a transistor, the collector current is found to vary from 1.10 mA to 1.50 mA when the base current varies from $4.3\mu A$ to $7.3\mu A$. What is the current gain of the transistor? **(3 marks)**

$$\beta = \frac{\Delta I_C}{\Delta I_B} = \frac{0.40\times10^{-3}}{3.0\times10^{-6}} \qquad \textbf{2 marks}$$

$$\beta = 130 \qquad \textbf{1 mark}$$

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



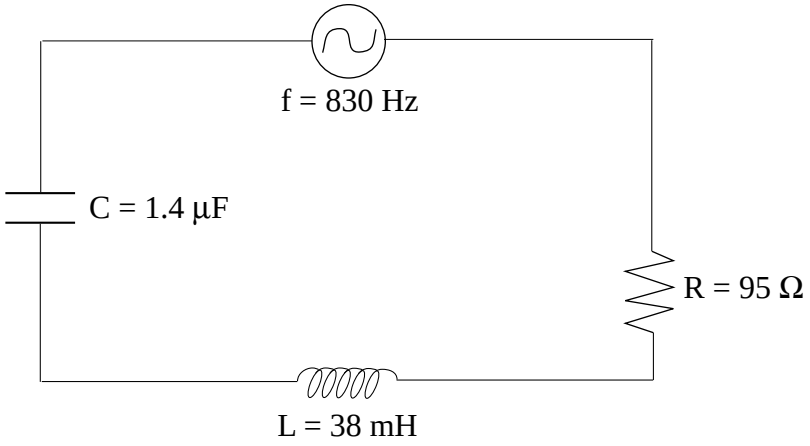
$$C_{11} = C_1 + C_2$$

$$= 1.0\ \mu F + 2.0\ \mu F = 3.0\ \mu F \qquad \textbf{2 marks}$$

$$\frac{1}{C_T} = \frac{1}{9.0\ \mu F} + \frac{1}{3.0\ \mu F} \qquad \textbf{2 marks}$$

$$C_T = 2.3\ \mu F$$

3. Calculate the impedance of the circuit shown below. **(5 marks)**



$X_L = 2\pi(830)\left(38\times10^{-3}\right) = 198\ \Omega$ **1 mark**

$X_C = \dfrac{1}{2\pi f C} = \dfrac{1}{2\pi(830)\left(1.4\times10^{-6}\right)} = 137\ \Omega$ **1 mark**

$Z = \sqrt{R^2 + \left(X_L - X_C\right)^2}$ **2 marks**

$= \sqrt{95^2 + (61)^2}$

$= 113\ \Omega$ **1 mark**

END OF SECTION III: AC Circuitry and Electronics

END OF KEY