Physics 12

August 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 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	D	2	I C4	16.	U	5	B	2	VI A6
2.	K	1	C	2	II A1	17.	U	5	A	2	VI A5, II A2
3.	U	1	B	2	I B8, C6	18.	U	5	A	2	VI B3, 2
4.	U	1	A	2	II A2, B3, 6	19.	U	5	B	2	VI B1, 2, 3
5.	H	1	D	2	II A5, 6, B2, 3, 6	20.	K	5	C	2	VII A1, 3
6.	K	2	D	2	III A1	21.	U	5	A	2	VII A6, 8, 10
7.	U	2	D	2	III A4	22.	U	5	B	2	VII A6, 8
8.	U	2	C	2	III B2, C5	23.	U	5	B	2	VII A6, 7
9.	U	3	A	2	IV B6, 8, II A5	24.	H	5	A	2	VII A10, 11
10.	K	4	D	2	V B1, 2	25.	K	6	B	2	VIII A2
11.	U	4	B	2	V A6	26.	U	6	C	2	VIII B2
12.	H	4	D	2	V A6, II B3	27.	U	6	D	2	VIII A4, 7
13.	U	4	A	2	V B12, III C9	28.	K	6	C	2	VIII B3
14.	H	4	C	2	V B6, 8	29.	U	6	B	2	VIII B11
15.	K	5	A	2	VI A7	30.	U	6	D	2	VIII B13

PART B: Written Response

Q	B	C	T	S	CGR
1.	1	U	1	7	II A2, 5, B5, 6
2.	2	H	2	9	III A6, C9
3.	3	U	3	7	IV B8
4.	4	U	4	7	II B6, V A6
5.	5	U	5	7	VI A1, 3
6.	6	U	6	7	VI B3, VIII A6
7.	7	H	6	4	VIII B12

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 A14, B5
	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 A9
	3.	13	U	8	5	III A13

or

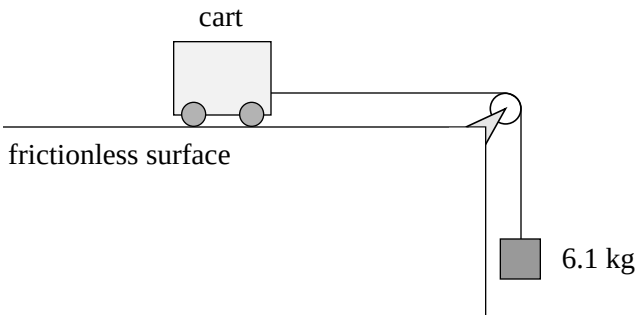
	Q	**B**	**C**	**T**	**S**	**CGR**
Section III	1.	14	U	9	3	I A3
	2.	15	U	9	4	I E5
	3.	16	U	9	5	I C2, 7

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

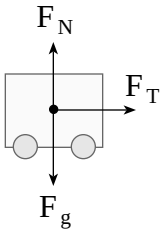
LEGEND:

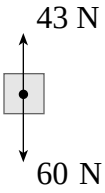
Q = Question Number
K = Keyed Response
B = Score Box Number
C = Cognitive Level
S = Score
T = Topic
CGR = Curriculum Guide Reference

1. In the diagram shown, the tension in the cord connecting the hanging mass and cart is 43 N.



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





← **2 marks for both**

b) Determine the mass of the cart. **(5 marks)**

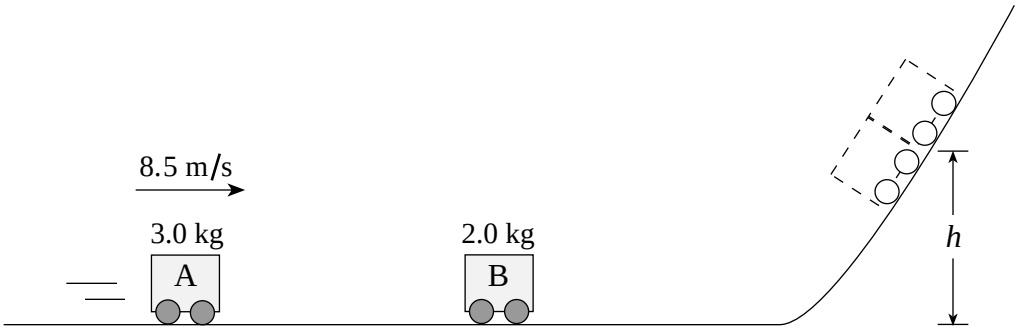
$$a = \frac{F_{net}}{m} = \frac{60 - 43}{6.1} = 2.75 \text{ m/s}^2$$

$$F_{net} = ma$$

$$F_T = ma$$

$$m = \frac{F_T}{a} = \frac{43}{2.75} = 16 \text{ kg}$$ ← **5 marks**

2. A 3.0 kg car A travelling 8.5 m/s on a frictionless track collides and sticks on to a stationary 2.0 kg car B.



a) The combined cars will reach what height h? **(5 marks)**

$P_0 = P_f$

$(3.0)(8.5)+(2.0)(0) = (5.0)v$ } ← **2 marks**

$v = 5.1$ m/s

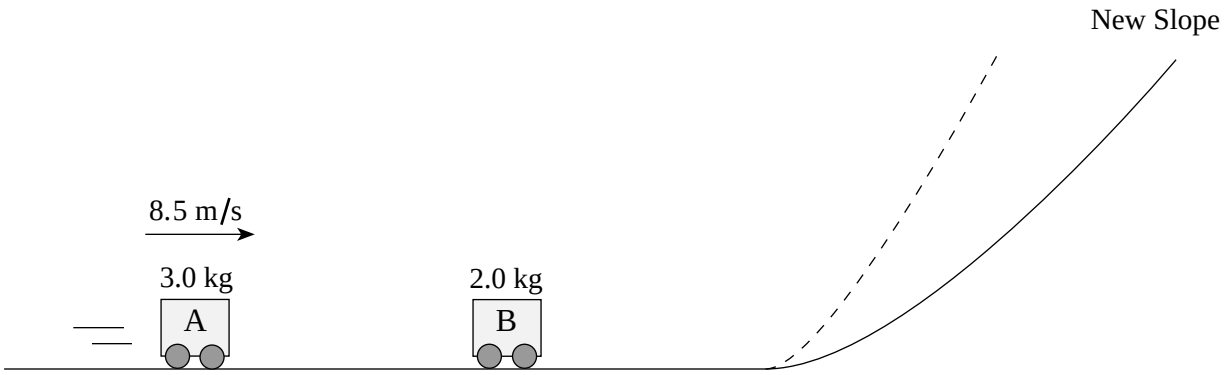
$E_{T_0} = E_{T_f}$

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

$\frac{1}{2}(5.0)(5.1)^2 = (5.0)(9.8)h$ } ← **3 marks**

$h = 1.3$ m

b) The steepness of the slope is decreased as shown below.



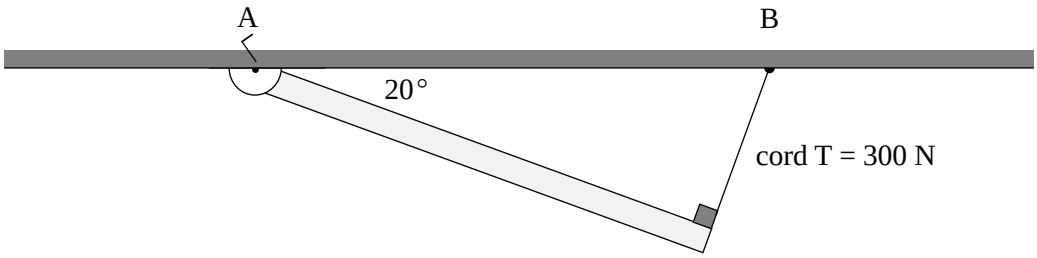
With this decreased slope, the combined cars will reach (check one response) **(1 mark)**

- ☐ a lesser height.
- ☑ the same height.
- ☐ a greater height.

c) Using principles of physics, explain your answer to b). **(3 marks)**

The steepness of the slope does not matter. All of the cars kinetic energy will be transferred to gravitational potential energy. Since the original kinetic energy of the cars has not changed, they must have the same potential. Therefore, they go to the same vertical height.

3. A 3.8 m uniform beam is attached to the ceiling with a hinge at A and a cord with a tension of 300 N at B.



Determine the mass of the beam. **(7 marks)**

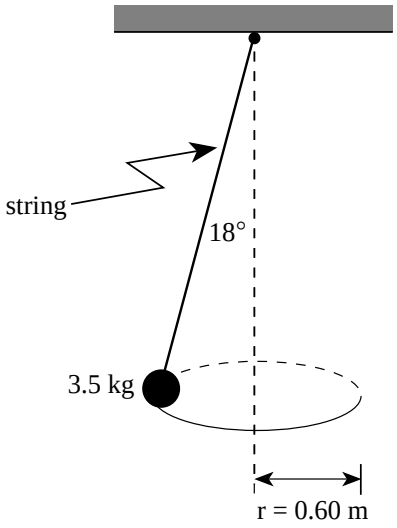
$\tau_c = \tau_{cc}$ ← **1 mark**

$\frac{\ell}{2} F \sin\theta = \ell F \sin\theta$ ← **3 marks**

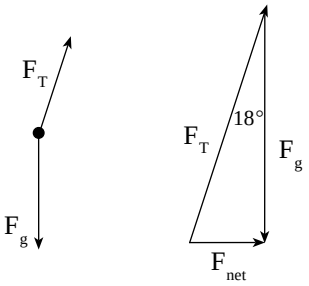
$1.9(9.8\ m)\sin 70° = 3.8(300)$ ← **2 marks**

$m = 65$ kg ← **1 mark**

4. A 3.5 kg object is suspended by a string and moves in a horizontal circle of radius 0.60 m. The tension in the string is 36 N.



a) What is the magnitude of the net force on the object? **(3 marks)**



$$\sin 18° = \frac{F_{net}}{F_T}$$

$$F_{net} = F_T \sin 18°$$

$$= (36)\sin 18°$$

$$F_{net} = 11 \text{ N} \qquad \leftarrow \textbf{3 marks}$$

b) What is the period of revolution of the object? **(4 marks)**

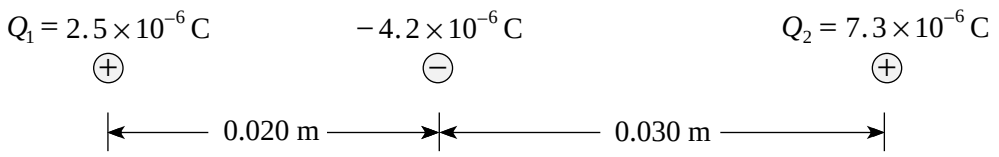
$$F_{net} = \frac{m4\pi^2 r}{T^2} \qquad \leftarrow \textbf{2 marks}$$

$$T^2 = \frac{m4\pi^2 r}{F_{net}} \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{(3.5)\left(4\pi^2\right)(0.60)}{11}$$

$$T = 2.7 \text{ s} \qquad \leftarrow \textbf{1 mark}$$

5. A -4.2×10^{-6} C charge, is placed between two stationary charges, Q_1 and Q_2, as shown below.



What is the magnitude and direction of the net force on the -4.2×10^{-6} C charge due to the **two** stationary charges? **(7 marks)**

$F_{net} = F_1 + F_2$ ← **1 mark**

$F_1 = \dfrac{kQ_1Q}{R^2} = \dfrac{9.00\times10^9\times2.5\times10^{-6}\times-4.2\times10^{-6}\text{ C}}{(0.02)^2} = -236.25\text{ N}\ \ (\text{left})$ ← **2 marks**

$F_2 = \dfrac{kQ_2Q}{R^2} = \dfrac{9.00\times10^9\times7.3\times10^{-6}\times-4.2\times10^{-6}\text{ C}}{(0.030)^2} = -306.6\text{ N}\ \ (\text{right})$ ← **2 marks**

236.25 N ⟵ ⟶ 306.6 N

$F_{net} = 306.6 - 236.25$ ← **1 mark**

$= 70\text{ N}\ \ (\text{right})$ ← **1 mark**

6. Electrons accelerated from rest through a potential difference of $300\ \text{V}$ enter a $4.1\times10^{-2}\ \text{T}$ magnetic field at right angles. What is the radius of curvature of the path taken by the electrons?

(7 marks)

$$PE = KE$$

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

$$\left(1.6\times10^{-19}\right)(300) = \frac{1}{2}\left(9.11\times10^{-31}\right)v^2$$

$$v = 1.0\times10^{7}\ \text{m/s}$$

← **3 marks**

$$net\ F_B = Fc$$

$$Bqv = \frac{mv^2}{r}$$

$$r = \frac{mv}{Bq} = \frac{\left(9.11\times10^{-31}\right)\left(1.0\times10^{7}\right)}{0.041\times\left(1.6\times10^{-19}\right)} = 1.4\times10^{-3}\ \text{m}$$

← **4 marks**

7. An ideal transformer is connected to a 12 V ac power supply. The light bulb connected to the secondary of the transformer is lit (Figure A). The transformer is then connected to a 12 V dc battery (Figure B).

Figure A

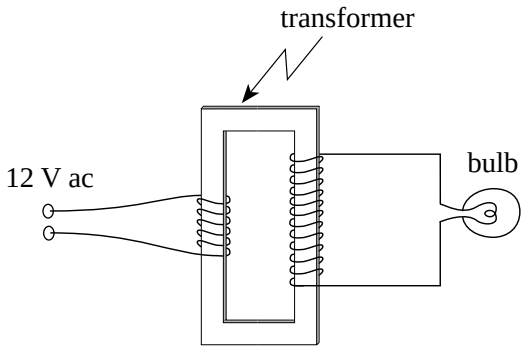
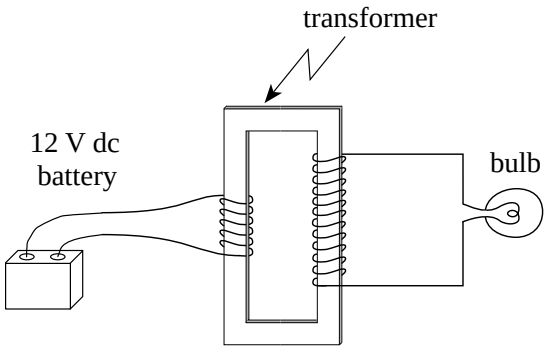


Figure B



a) The bulb will (check one response) **(1 mark)**

- ☑ not be lit.
- ☐ be dimmer.
- ☐ have the same brightness.
- ☐ be brighter.

b) Using principles of physics, explain your answer to a). **(3 marks)**

Faraday's law states that an induced current is produced by a changing flux. Since a battery provides a dc current there is no flux change in the transformer. Therefore, there is no induced current.

PART C: ELECTED TOPICS

SECTION I: Quantum Mechanics

1. What is the wavelength of a 2.1 eV photon? **(3 marks)**

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

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

$$= \frac{\left(4.14\times10^{-15}\right)\left(3.0\times10^{8}\right)}{2.1} \qquad \leftarrow \textbf{1 mark}$$

$$= 590 \text{ nm} \qquad \leftarrow \textbf{1 mark}$$

2. What is the de Broglie wavelength of an electron with a kinetic energy of 75 eV? **(4 marks)**

$$75\ eV = 1.2\times10^{-17} \text{ J} \qquad \leftarrow \textbf{1 mark}$$

$$\frac{1}{2}\left(9.11\times10^{-31}\right)v^2 = 1.2\times10^{-17}$$

$$v = 5.13\times10^{6} \text{ m/s} \qquad \leftarrow \textbf{1 mark}$$

$$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{\left(9.11\times10^{-31}\right)\left(5.13\times10^{6}\right)}$$

$$\lambda = 1.4\times10^{-10} \text{ m} \qquad \leftarrow \textbf{2 marks}$$

3. The longest wavelength of light that will emit photoelectrons from a metal surface is 2.4×10^{-7} m. What is the maximum kinetic energy of the electrons emitted by light of wavelength 1.1×10^{-7} m?

(5 marks)

$$W = hf_0$$

$$W = \frac{\left(6.63\times10^{-34}\right)\left(3.00\times10^{8}\right)}{2.4\times10^{-7}}$$

$$= 8.29\times10^{-19}\ \text{J} \qquad \leftarrow \textbf{2 marks}$$

$$E_k = hf - W$$

$$= \frac{\left(6.63\times10^{-34}\right)\left(3.00\times10^{8}\right)}{1.1\times10^{-7}} - 8.29\times10^{-19}$$

$$= 9.8\times10^{-19}\ \text{J} \qquad \leftarrow \textbf{3 marks}$$

END OF SECTION I: Quantum Mechanics

SECTION II: Fluid Theory

1. A piece of styrofoam can withstand a maximum pressure of 2.5×10^3 Pa without being crushed. A 120 kg block is to be placed on the styrofoam. What is the minimum area of the bottom of the block that would prevent crushing the styrofoam? **(3 marks)**

$$P = \frac{F}{A} \qquad \leftarrow \textbf{1 mark}$$

$$A = \frac{F}{P}$$

$$= \frac{mg}{P} \qquad \leftarrow \textbf{1 mark}$$

$$= \frac{(120)(9.8)}{2.5\times10^3}$$

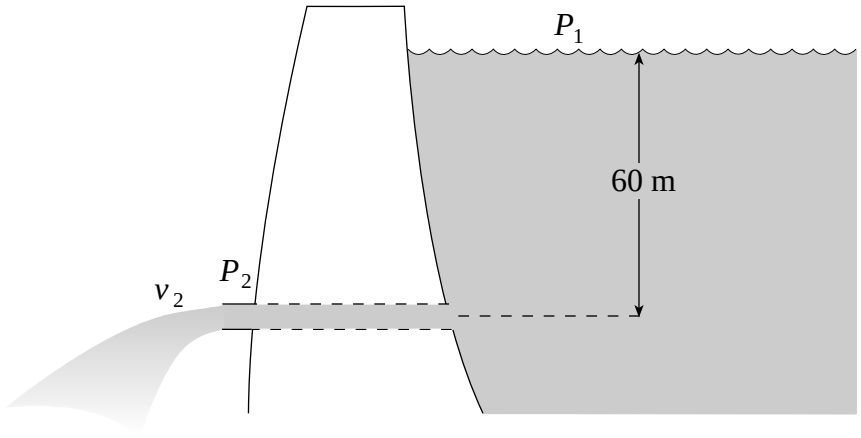
$$= 0.47 \text{ m}^2 \qquad \leftarrow \textbf{1 mark}$$

2. A weather balloon has a total weight of 18 N when it is inflated to a volume of 6.0 m^3. What maximum equipment load (in Newtons) can it lift? **(4 marks)**

$$F_B = \rho g V$$
$$= (1.29)(9.8)(6.0)$$
$$= 75.8 \text{ N}$$
} ← **2 marks**

$$F_B = W_{balloon} + W_{equipment}$$
$$75.8 \text{ N} = 18 \text{ N} + W_{equipment}$$
$$W_{equipment} = 58 \text{ N}$$
} ← **2 marks**

3. The outlet of a fresh water dam is 60 m below the surface as shown. The atmospheric pressure at the outlet P_2 is 760 Pa **greater** than at the surface P_1.



What is the speed of the water v_2 at the outlet? **(5 marks)**

$$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^{\,2} = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^{\,2} \quad \leftarrow \textbf{1 mark}$$

$$\text{let } v_1 = 0;\ \ h_2 = 0 \quad \leftarrow \textbf{1 mark}$$

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

$$(-760) + (1\,000)(9.8)(60) = \frac{1}{2}(1\,000)v_2^{\,2} \quad \leftarrow \textbf{2 marks}$$

$$v_2 = 34 \text{ m/s} \quad \leftarrow \textbf{1 mark}$$

END OF SECTION II: Fluid Theory

SECTION III: AC Circuitry and Electronics

1. A 12 V battery is connected to a capacitor. If 4.2×10^{-4} C of charge flows from the battery to fully charge this capacitor, what is the value of the capacitor? **(3 marks)**

$Q = CV$ ← **1 mark**

$C = \frac{Q}{V} = \frac{4.2\times10^{-4}}{12}$ ← **1 mark**

$C = 3.5\times10^{-5}$ F ← **1 mark**

2. A transistor circuit has a current gain of 430. When the base current is $6.00\ \mu$A the collector current is 1.15 mA. What is the collector current when the base current is $7.50\ \mu$A? **(4 marks)**

$\beta = \frac{\Delta I_C}{\Delta I_B}$ ← **1 mark**

$\Delta I_C = \beta \Delta I_B$

$= (430)(7.50 - 6.00)\times10^{-6}$

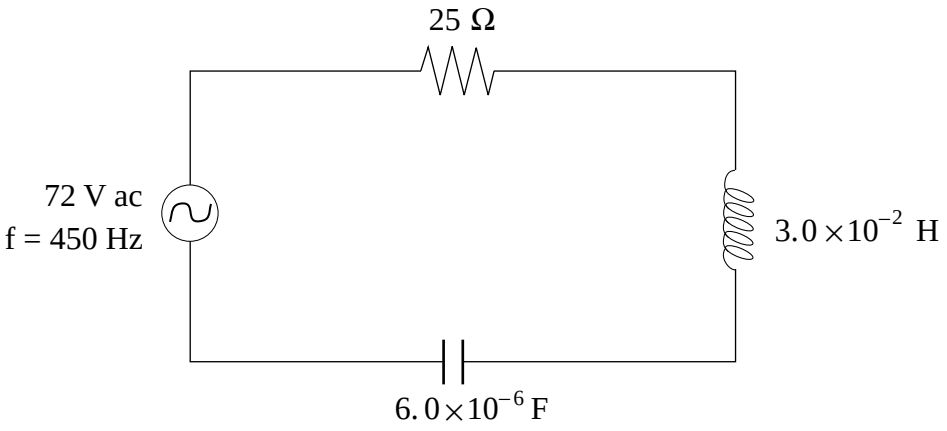
$\Delta I_C = 6.45\times10^{-4}$ A ← **2 marks**

$I_C - 1.15\times10^{-3} = 6.45\times10^{-4}$

$I_C = 1.80\times10^{-3}$ A

$= 1.8$ mA ← **1 mark**

3. What is the current in the circuit shown below? **(5 marks)**



$X_L = 2\pi fL$

$= 2\pi(450)\left(3.0\times10^{-2}\right)$

$= 85\ \Omega$ ← **1 mark**

$X_C = \dfrac{1}{2\pi fC} = \dfrac{1}{2\pi(450)\left(6.0\times10^{-6}\right)}$

$= 59\ \Omega$ ← **1 mark**

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

$= \sqrt{25^2 + (85-59)^2}$

$Z = 36\ \Omega$ ← **2 marks**

$I = \dfrac{V}{Z} = \dfrac{72}{36}$

$I = 2.0$ A ← **1 mark**

END OF SECTION III: AC Circuitry and Electronics

END OF KEY