JANUARY 1994 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 Physics
8. Fluid Theory
9. AC Circuitry and Electronics

PART A: MULTIPLE-CHOICE QUESTIONS

Q	C	T	K	S	CGR	Q	C	T	K	S	CGR
1.	K	1	D	2	I B1	16.	U	5	B	2	VI A6
2.	K	1	D	2	II A1	17.	U	5	C	2	VI B4
3.	U	1	A	2	I B8	18.	U	5	A	2	VII A8
4.	U	1	B	2	II A6	19.	U	5	C	2	VII A2, A6
5.	H	1	D	2	II B6, A2	20.	U	5	D	2	VII A10
6.	U	2	A	2	III D2	21.	U	5	C	2	VII A8, A11
7.	U	3	B	2	IV A3	22.	H	5	C	2	VII A8
8.	U	3	B	2	IV B8	23.	K	6	C	2	VIII A2
9.	K	4	C	2	V B11	24.	K	6	D	2	VIII B3
10.	U	4	D	2	V B5	25.	U	6	A	2	VIII A3, VI A4
11.	U	4	C	2	V B3	26.	U	6	B	2	VIII A10
12.	U	4	B	2	V A4	27.	U	6	C	2	VIII B7
13.	H	4	D	2	V A4, A6	28.	U	6	C	2	VIII B11
14.	K	5	B	2	VI A4	29.	U	6	A	2	VIII B13
15.	K	5	B	2	VII A1	30.	H	6	B	2	VIII A6, III C9

PART B: PROBLEMS

Q	B	C	T	S	CGR
1.	1	U	1	7	I C5, C6
2.	2	U	2	7	III A6
3a.	3	U	3	2	IV A2
3b.	4	U	3	5	IV A2
4.	5	U	4	7	V B6
5a.	6	U	5	5	VII A7, A8
5b.	7	H	5	4	VII A7, A8
6.	8	U	6	7	VIII A5, A8
7.	9	H	2	4	III A5

PART C: ELECTIVE TOPICS

Only **ONE** of the following sections will be chosen. Score only *one* set of boxes: (10, 11, 12) **OR**(13,14,15) **OR** (16, 17, 18). Maximum possible score for Part C is 12.

	Q	B	C	T	S	CGR
SECTION I	1.	10	U	8	3	II A14
	2.	11	U	8	4	II B6
	3.	12	U	8	5	II B6, A6
			OR			
SECTION II	1.	13	U	9	3	III A6, A2
	2.	14	U	9	4	III B7, B4
	3.	15	U	9	5	III A13, A5
			OR			
SECTION III	1.	16	U	7	3	I E5
	2.	17	U	7	4	I A7, A3
	3.	18	U	7	5	I B3, C2, C7

Multiple-choice total	=	60	(30 questions)
Written-response total	=	60	(10 questions)
EXAM TOTAL	**=**	**120**	

KEY: **Q** = Question; **B** = Score box number; **C** = Cognitive level; **T** = Topic; **S** = Score; **CGR** = Curriculum Guide Reference; **K** = Keyed response

1. A 1.50 kg projectile is launched at 18.0 m/s from level ground. The launch angle is $26.0°$ above the horizontal. (Assume negligible friction.)

a) What is the maximum height reached by this projectile? **(5 marks)**

$v_x = v_o \sin 26° = 7.89 \text{ m/s}$ **1 mark**

$$\left.\begin{aligned} v_f^2 &= v_0^2 + 2ad \\ 0 &= 7.89^2 + 2(-9.8)(d) \\ d &= 3.18 \text{ m} \end{aligned}\right\}$$ **4 marks**

Alternate Energy Solution:

$E_{TOTAL} = \frac{1}{2}mv^2 = \frac{1}{2}(1.5)(18.0)^2 = 243 \text{ J}$ **1½ marks**

$E_{TOTAL} = E_{p_{(TOP)}} + E_{k_{TOP}}$ **1 mark**

$$\left.\begin{aligned} E_T &= mgh + \frac{1}{2}mv_f{}^2 \\ 243 &= (1.5)(9.8)h + \frac{1}{2}(1.5)(18\cos 26)^2 \\ 243 &= 14.7h + 196 \end{aligned}\right\}$$ **1½ marks**

$3.20 = h$ **1 mark**

b) How fast will the projectile be travelling when it is at its maximum height? **(2marks)**

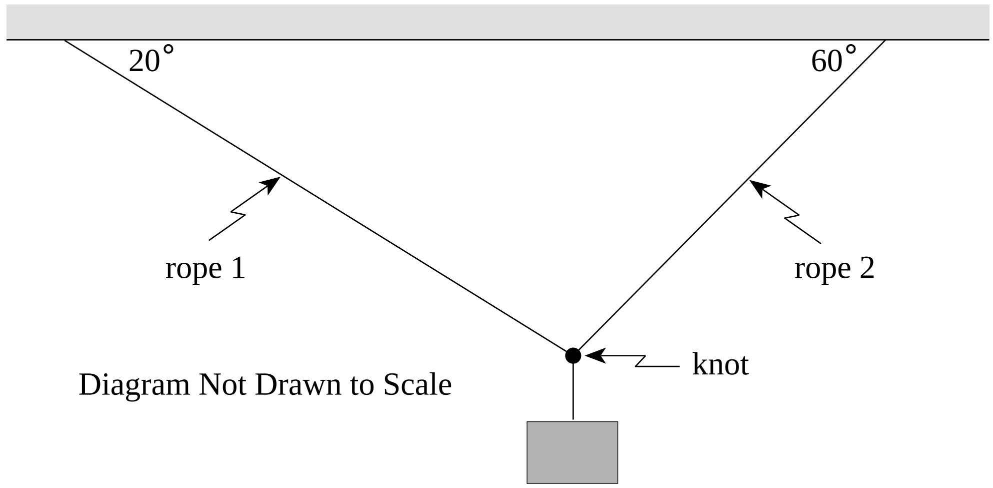
$v = v_o \cos 26° = 16.2 \text{ m/s}$ **2 marks**

2. A 5.20 kg block sliding at 9.40 m/s across a horizontal frictionless surface collides head on with a stationary 8.60 kg block. The 5.20 kg block rebounds at 1.80 m/s. How much kinetic energy is lost during this collision? **(7 marks)**

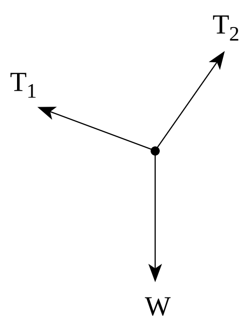
$$\left.\begin{aligned} m_1v_1 + m_2v_2 &= m_1v_1' + m_2v_2' \\ (5.20)(9.40) &= (5.20)(-1.80) + (8.60)v_2' \\ v_2' &= 6.77 \text{ m/s} \end{aligned}\right\}$$ **4 marks**

$$\left.\begin{aligned} E_k(\text{before}) &= \frac{1}{2}m_1v_1^2 = 229.7 \text{ J} \\ E_k(\text{after}) &= \frac{1}{2}m_1v_1^{2\prime} + \frac{1}{2}m_2v_2^{2\prime} \\ &= 8.424 + 197.2 \\ &= 205.6 \text{ J} \\ \text{LOST} &= 24.12 \text{ J} \\ \Delta E &= 24.1 \text{ J} \end{aligned}\right\}$$ **3 marks**

3. A 750 N weight is supported by two ropes fastened together by a knot, as shown in the diagram below.

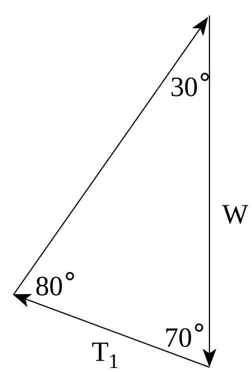


a) Draw a free-body diagram showing the forces acting on the knot. **(2 marks)**



2 marks

b) What is the tension in rope 1? **(5 marks)**



$$\left.\begin{aligned}\frac{T_1}{\sin 30^\circ} &= \frac{W}{\sin 80^\circ}\\ T_1 &= 381\text{ N}\end{aligned}\right\}$$ **5 marks**

OR

$$\left.\begin{aligned}T_1\cos 20^\circ &= T_2\cos 60\\ T_1\sin 20 + T_2\sin 60 &= 750\\ T_1 &= 381\text{ N}\end{aligned}\right\}$$ **5 marks**

4. A satellite travels in a circular orbit at a height of one Earth radius above the surface of the Earth. What is the satellite's orbital period? **(7 marks)**

$$\left.\frac{m_s 4\pi^2 R}{T^2} = \frac{G m_e m_s}{R^2}\right\} \quad \textbf{3 marks}$$

$$\left.T = \left(\frac{4\pi^2 R^3}{G m_e}\right)^{\frac{1}{2}}\right\} \quad \textbf{2 marks}$$

$$\left.= \left(\frac{4\pi^2 (1.276\times 10^7\,\text{m})^3}{6.67\times 10^{-11}\,\text{N}\cdot\text{m}^2/\text{kg}^2 \times 5.98\times 10^{24}\,\text{kg}}\right)^{\frac{1}{2}}\right\} \quad \textbf{2 marks}$$

OR

$$\left.\begin{aligned} a_c = a_g &= \left(\frac{1}{2}\right)^2 \times 9.8\ \text{m/s}^2 \\ &= 2.45\ \text{m/s}^2 \end{aligned}\right\} \quad \textbf{2 marks}$$

$$\left.\therefore \frac{4\pi^2 R}{T^2} = 2.45\ \text{m/s}^2\right\} \quad \textbf{3 marks}$$

$$\left.\begin{aligned} \therefore T &= \left(\frac{4\pi^2 \times\ 1.276\times 10^7\,\text{m}}{2.45\ \text{m/s}^2}\right)^{\frac{1}{2}} \\ &= 1.4\times 10^4\ \text{s} \end{aligned}\right\} \quad \textbf{2 marks}$$

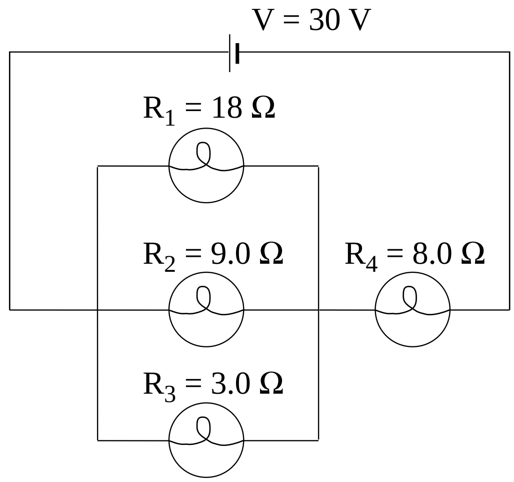
OR

$$\left.\frac{R^3_{\text{MOON}}}{T^2_{\text{MOON}}} = \frac{R^3_S}{T^2_S}\right\} \quad \textbf{2 marks}$$

$$\left.T_S^2 = \frac{\left(12.76\times 10^6\ \text{m}\right)^3 \left(2.36\times 10^6\ \text{s}\right)^2}{\left(3.84\times 10^8\ \text{m}\right)^3}\right\} \quad \textbf{3 marks}$$

$$\left.T_S = 1.44\times 10^4\ \text{s}\right\} \quad \textbf{2 marks}$$

5. a) Find the current in the 8.0 Ω bulb shown below. **(5 marks)**



$\frac{1}{R} = \frac{1}{18} + \frac{1}{9.0} + \frac{1}{3.0} = \frac{9}{18}$ ← **1 mark**

$R_p = 2.0\ \Omega$ ← **1 mark**

2 marks

$R_T = 2.0\ \Omega + 8.0\ \Omega$ ← **½ mark**

$= 10.0\ \Omega$ ← **1 mark**

1½ marks

$I = \frac{V}{R}$ ← **½ mark**

$= \frac{30}{10.0} = 3.0\ \text{A}$ ← **1 mark**

1½ marks

b) (i) The 3.0 Ω bulb is removed from the circuit so that only 3 bulbs remain.
The 8.0 Ω bulb will now: **(Circle one)** **(1 mark)**

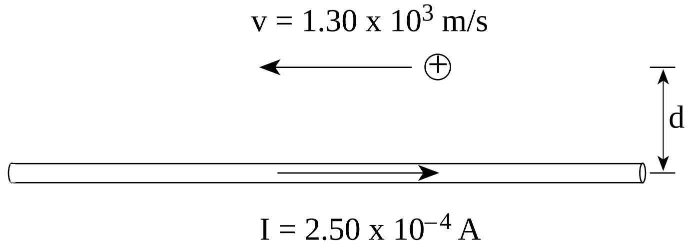
A. be dimmer.
B. be brighter.
C. remain the same.

A. be dimmer.

(ii) Using principles of electrical circuits, explain your answer to b(i). **(3 marks)**

With fewer bulbs in the parallel combination, the overall resistance of the circuit will be greater. The total current flow from the battery will now be smaller. Since the total current must flow through the 8.0 Ω resistor, it will be dimmer.

6. A proton with a speed of 1.30×10^3 m/s travels parallel to a horizontal wire carrying a current of 2.50×10^{-4} A as shown.



If the magnetic force on the proton is 1.64×10^{-26} N, at what distance **d** is the proton travelling above the wire? **(7 marks)**

$F = q\,v\,B$ **2 marks**

$F = q\,v\left(\dfrac{\mu_0 I}{2\pi d}\right)$ **3 marks**

$$d = q\,v\,\frac{\mu_0 I}{2\pi F}$$

$$= \frac{(1.6\times 10^{-19})(1.30\times 10^{3})(4\pi\times 10^{-7})(2.50\times 10^{-4})}{2\pi\,(1.64\times 10^{-26})}$$

$$= 6.34\times 10^{-1}\ \text{m}$$

2 marks

7. Two gliders having equal masses, each travelling along a level frictionless track at the same speed, approach each other head on. They stick together on impact and remain stationary at the point of impact. Does this situation mean that momentum has been lost during this particular collision? State your answer with supporting arguments which use principles of physics. **(4 marks)**

Conservation of momentum is a vector concept. As both of these gliders have the same mass and speed, the magnitude of their momentums is the same, but their directions are opposite. Thus one glider has a positive momentum, the other a negative. Therefore, the sum of the momentums before impact is ZERO. If momentum is conserved, then the sum of the momentums after the collision must also equal ZERO. After the collision, the two stationary gliders have a sum of ZERO momentum, and momentum has been conserved.

PART C: ELECTED TOPICS

SECTION I: Quantum Physics

1.	What is the momentum of an electron whose de Broglie wavelength is 1.46 x 10^{-10} m?	**(3 marks)**

$$\lambda = \frac{h}{p} \rightarrow p = \frac{h}{\lambda}$$ $\leftarrow$ **1 mark**

$$= \frac{6.63 \times 10^{-34}}{1.46 \times 10^{-10}}$$ $\leftarrow$ **1 mark**

$$= 4.54 \times 10^{-24}\,\text{kg m/s}$$ $\leftarrow$ **1 mark**

2.	An electron in the second level (n = 2) of an atom has an energy of –30.6 eV. How many protons does this atom have in its nucleus? (Express your answer as a whole number.)	**(4marks)**

$$E_n = (-13.6\text{ eV})\frac{Z^2}{n^2}$$ $\leftarrow$ **1 mark**

$$-30.6 = -13.6\text{ eV}\frac{Z^2}{2^2}$$ $\leftarrow$ **2 marks**

$$Z = 3$$ $\leftarrow$ **1 mark**

$\therefore$ There are 3 protons.

3. An electron is in the sixth excited state (n = 7) of a hydrogen atom. When it makes a transition to a lower energy level, the emitted photon has a wavelength of 1.01 x 10^{-6} m. What is the quantum number of the lower energy level? (Express your answer as a whole number.) **(5 marks)**

$$\begin{aligned}\Delta E &= \frac{hc}{\lambda} \\ &= \frac{(4.14\times10^{-15}\,\text{eV}\cdot\text{s})(3.00\times10^{8}\,\text{m/s})}{1.01\times10^{-6}\,\text{m}} \\ &= 1.23\ \text{eV}\end{aligned}$$

1 mark

For n = 7

$$\begin{aligned}&= \frac{-13.6\ \text{eV}}{7^2} \\ &= -0.278\ \text{eV}\end{aligned}$$

1 mark

$$\begin{aligned}E_x &= -0.278\ \text{eV} - 1.23\ \text{eV} \\ &= -1.51\ \text{eV}\end{aligned}$$

2 marks

$$\begin{aligned}\therefore x &= \left(\frac{-13.6\ \text{eV}}{-1.51\ \text{eV}}\right)^{\frac{1}{2}} \\ &= 3\end{aligned}$$

1 mark

END OF SECTION I: Quantum Physics

SECTION II: Fluid Theory

1. A glass bottle of soda is sealed with a screw cap. The gauge pressure inside the bottle is 4.90×10^4 Pa. The area of the bottom of the screw cap is 1.20×10^{-3} m^2. What force must the screw threads exert on the glass to keep the cap in place? **(3 marks)**

$$F = PA = (4.90 \times 10^4)(1.20 \times 10^{-3})$$

$$F = 58.8 \text{ N}$$

2. At the start of a trip, the absolute pressure in a car's tires is measured to be 2.91×10^5 Pa at a temperature of 10° C. At the end of the trip, the absolute pressure is measured to be 3.11×10^5 Pa. Neglecting the expansion of the tires, what is the temperature (in degrees Celsius) inside the tires at the end of the trip? **(4 marks)**

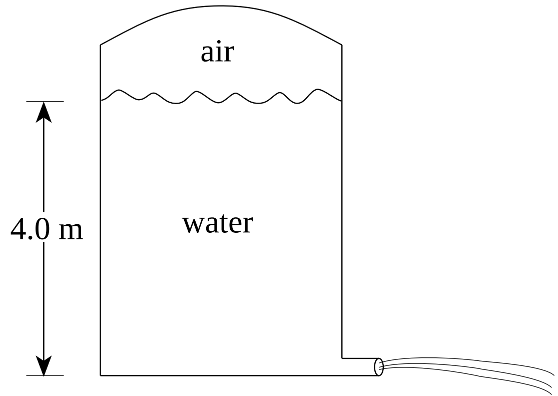
$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}, \text{ where } V_1 = V_2$$

$$T_1 = 273 + 10 = 283$$

$$T_2 = \frac{P_2 T_1}{P_1} = \frac{(3.11 \times 10^5)(283)}{2.91 \times 10^5}$$

$$T_2 = 302 \text{ K} = 29^\circ\text{C}$$

3. In a closed tank, the gauge pressure of the air above the water is 5.00×10^5 Pa. The water leaves the tank through a nozzle 4.0 m below the surface of the water as shown.



What is the speed at which the water leaves the nozzle? **(5 marks)**

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

$$v_1 = 0; \quad h_2 = 0$$

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

$$(5.00 \text{ x } 10^5) + (1000)(9.8)(4.0) = \frac{1}{2}(1000)v_2^2$$

$$v_2 = 33 \text{ m/s}$$

END OF SECTION II: Fluid Theory

SECTION III: AC Circuitry and Electronics

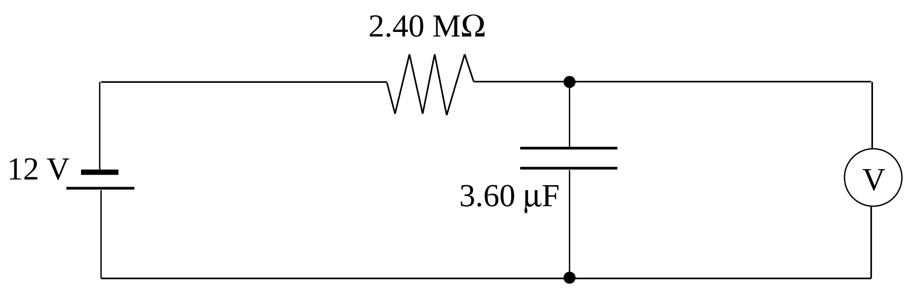
1. In a certain transistor the collector current changes from 1.20 mA to 1.75 mA when the base current varies from 4.6 μA to 8.6 μA. What is the current gain for this transistor? **(3 marks)**

$$\beta = \frac{\Delta I_c}{\Delta I_B} = \frac{1.75\text{ mA} - 1.20\text{ mA}}{8.6\ \mu\text{A} - 4.6\ \mu\text{A}}$$

$$= \frac{5.5 \times 10^{-4}\text{ A}}{4.0 \times 10^{-6}\text{ A}}$$

$$= 1.4 \times 10^{2}$$

2. A 2.40 MΩ resistor and a 3.60 μF capacitor are connected in an RC circuit as shown.



a) What is the time constant for this circuit? **(2 marks)**

$$\tau = RC$$

$$= (2.40 \times 10^{6})(3.60 \times 10^{-6})$$

$$= 8.64\text{ s}$$

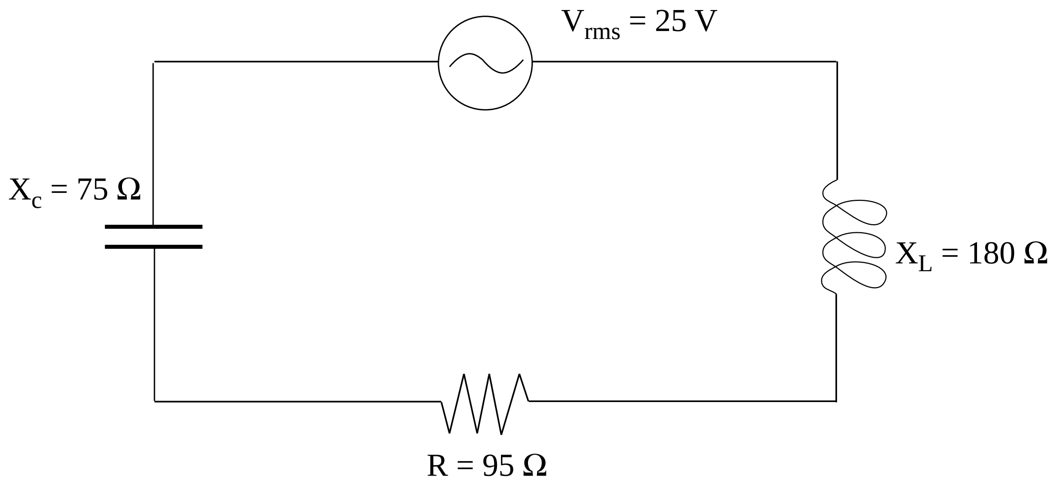
b) What is the charge stored in the capacitor at the instant the voltmeter reads 9.00 V? **(2 marks)**

$$Q = CV$$

$$= (3.60 \times 10^{-6}\text{ F})(9.00\text{ V})$$

$$= 3.24 \times 10^{-5}\text{ C}$$

3. A series circuit has a resistance of 95 Ω, an inductive reactance of 180 Ω and a capacitive reactance of 75 Ω.



a) If the coil has an inductance of 35.0 mH, what is the applied frequency? **(2 marks)**

$$X_L = 2\pi fL$$

$$f = \frac{X_L}{2\pi L}$$

$$= \frac{180\ \Omega}{2\pi\,(35\ \text{mH})}$$

$$= 819\ \text{Hz}$$

b) What current flows in the circuit? **(3 marks)**

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

$$= \sqrt{95^2 + (180 - 75)^2}$$

$$= 142\ \Omega$$

$$I_{rms} = \frac{V_{rms}}{Z}$$

$$= \frac{25}{141.6}$$

$$I_{rms} = 0.18\ \text{A}$$

END OF KEY