

**AUGUST 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**

<b>Q</b>	<b>C</b>	<b>T</b>	<b>K</b>	<b>S</b>	<b>CGR</b>	<b>Q</b>	<b>C</b>	<b>T</b>	<b>K</b>	<b>S</b>	<b>CGR</b>
1.	K	1	C	2	II A 2	16.	U	5	C	2	VI A 5, II A 5
2.	K	1	B	2	IC 3, 4	17.	U	5	C	2	VI B 2
3.	U	1	B	2	IA 1	18.	U	5	C	2	VI B 3
4.	U	1	A	2	II A 2, 5	19.	U	5	D	2	VI B 4
5.	H	1	A	2	II B 6, 3	20.	K	5	C	2	VII A 8
6.	K	2	A	2	III A 7	21.	U	5	C	2	VII A 2, 6
7.	H	2	D	2	III A 4	22.	U	5	C	2	VII B 4
8.	U	2	D	2	III A 3	23.	H	5	B	2	VII A 11
9.	U	3	C	2	IV B 8	24.	K	6	D	2	VIII B 14
10.	H	3	C	2	IV B 8, 3	25.	U	6	C	2	VIII A 9
11.	K	4	B	2	VB 7	26.	U	6	B	2	VIII A 3, 6
12.	U	4	A	2	VB 2, 5	27.	U	6	A	2	VIII A 8
13.	U	4	B	2	VB 6	28.	K	6	A	2	VIII B 12
14.	H	4	B	2	VB 14	29.	U	6	B	2	VIII B 11
15.	K	5	B	2	VI A 7	30.	H	6	B	2	VIII A 7, IV B 8

**PART B: WRITTEN-RESPONSE**

<b>Q</b>	<b>B</b>	<b>C</b>	<b>T</b>	<b>S</b>	<b>CGR</b>
1.	1	U	1	7	IC 6
2.	2	U	2	9	III C 9
3.	3	U	3	7	IV A3, II A6
4.	4	U	4	7	VB 12
5.	5	U	5	7	VII A 6, 10
6.	6	U	6	7	VIII A 9, B 2
7.	7	H	4	4	V A 5, II B 3

**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.

	<b>Q</b>	<b>B</b>	<b>C</b>	<b>T</b>	<b>S</b>	<b>CGR</b>
Section I	1.	8	U	7	3	II A6
	2.	9	U	7	4	II A9
	3.	10	U	7	5	II B6, A4

**or**

	<b>Q</b>	<b>B</b>	<b>C</b>	<b>T</b>	<b>S</b>	<b>CGR</b>
Section II	1.	11	U	8	3	III B 12
	2.	12	U	8	4	III A 11
	3.	13	U	8	5	III A2, 13

**or**

	<b>Q</b>	<b>B</b>	<b>C</b>	<b>T</b>	<b>S</b>	<b>CGR</b>
Section III	1.	14	U	9	3	I A 3
	2.	15	U	9	4	I E 8
	3.	16	U	9	5	I C2, 7

Multiple-choice = 60 (30 questions)

Written-response = 60 (10 questions)

**Total = 120 marks**

**LEGEND:**

**Q** = Question

**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 35 m/s at an angle of  $24^\circ$  above the horizontal. Friction is negligible.

a) What is the time of flight of this projectile?

**(3 marks)**

$$\begin{aligned}t &= -\frac{2v \sin \theta}{a} \\&= \frac{-2(35) \cdot \sin 24}{-9.8} \\&= 2.9 \text{ s} \quad \leftarrow \text{3 marks}\end{aligned}$$

b) What is the velocity (magnitude and direction) of this projectile 2.5 s after launch? **(4 marks)**

$$v_x = v \cdot \cos \theta$$

$$= 35 \text{ m/s} \cdot \cos 24$$

$$= 32.0 \text{ m/s}$$

**← 1 mark**

$$v_{y_f} = v_{y_i} + at$$

$$= (35 \text{ m/s} \cdot \sin 24) + (-9.8 \text{ m/s}^2 \cdot 2.5 \text{ s})$$

$$= -10.3 \text{ m/s}$$

**← 1 mark**

$$\therefore v_R^2 = v_x^2 + v_{y_f}^2$$

$$= (32.0 \text{ m/s})^2 + (10.3 \text{ m/s})^2$$

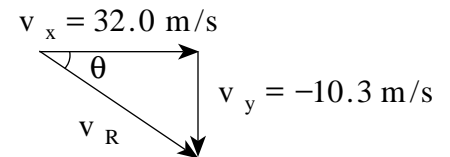
$$\therefore v_R = 34 \text{ m/s}$$

**← 1 mark**

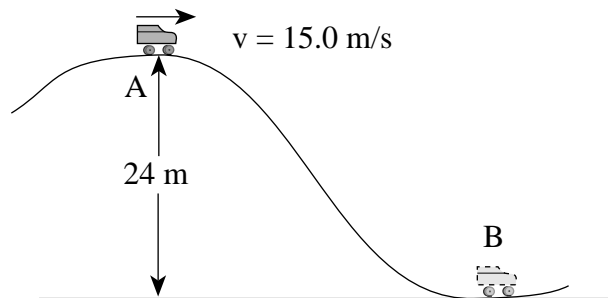
$$\theta = \tan^{-1}\left(\frac{10.3 \text{ m/s}}{32.0 \text{ m/s}}\right)$$

$$= 18^\circ \text{ (below the horizontal)}$$

**← 1 mark**



2. A 150 kg roller coaster car passes the crest of a hill at 15.0 m/s.



a) What is the speed of the car at point **B** at the bottom of the hill? (Neglect friction.) **(5 marks)**

$$E_A = E_B$$

$$E_{k_A} + E_{p_A} = E_{k_B} + E_{p_B} \quad \leftarrow \text{2 marks}$$

$$\frac{1}{2}mv_A^2 + mgh_A = \frac{1}{2}mv_B^2 + 0 \quad \leftarrow \text{1 mark}$$

$$\frac{1}{2}v_A^2 + gh_A = \frac{1}{2}v_B^2 \quad \leftarrow \text{1 mark}$$

$$v_B^2 = 2gh_A + v_A^2$$

$$= 2 \cdot 9.8 \text{ m/s}^2 \cdot 24 \text{ m} + (15 \text{ m/s})^2$$

$$\therefore v_B = 26 \text{ m/s} \quad \leftarrow \text{1 mark}$$

b) i) If the mass of the roller coaster car is increased by adding a passenger, how will the speed at **B** now compare to your answer for part a)? (Circle one) **(1 mark)**

A. equal to

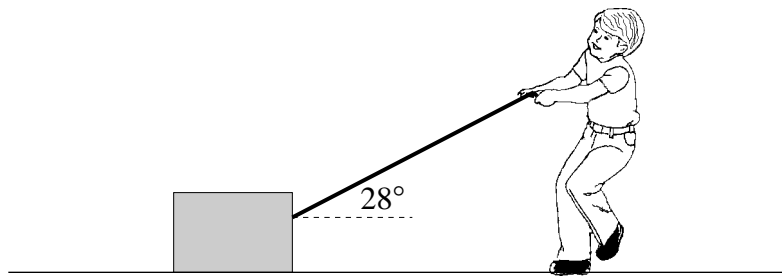
B. less than

C. greater than

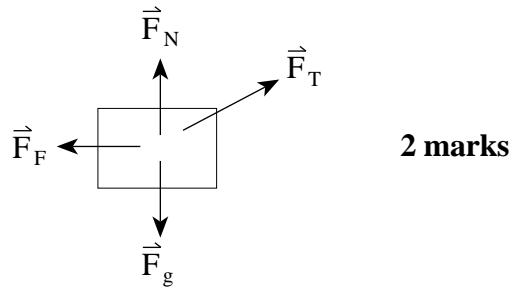
ii) Explain your answer using principles of physics. **(3 marks)**

The speed will be the same as in a). This is a direct transfer of potential energy to kinetic energy. Both potential energy and kinetic energy have the mass term in them. If you increase the mass, both potential energy and kinetic energy increase by the same amount.

3. A 60 kg block rests on the ground. A student exerts a 320 N force on the block by pulling on a rope, but friction prevents the block from moving.



- a) Draw and label a free body diagram showing all forces acting on the block. **(2 marks)**



- b) Calculate the force of friction on the block. **(2 marks)**

$$\begin{aligned} F_F &= F_T \cos 28^\circ \\ &= 283 \text{ N} \quad \leftarrow \text{2 marks} \end{aligned}$$

c) Calculate the normal force exerted by the ground on the block.

**(2 marks)**

$$\begin{aligned}F_N &= F_g - F_T \sin 28^\circ \\ &= 588 - 150 \quad \mathbf{2 \text{ marks}} \\ &= 438 \text{ N}\end{aligned}$$

d) Calculate the minimum coefficient of friction between the block and the ground.

**(1 mark)**

$$\begin{aligned}F_F &= \mu F_N \quad \mathbf{1 \text{ mark}} \\ \mu &= 0.65\end{aligned}$$

4. A 1 250 kg rocket rests on the surface of the Earth. To what maximum distance from the Earth's centre would the rocket be lifted if  $2.5 \times 10^{10}$  J of work were done on it? **(7 marks)**

$$W = \Delta E_p \quad \leftarrow \text{1 mark}$$

$$= E_p' - E_p \quad \leftarrow \text{1 mark}$$

$$= -\frac{GMm}{r'} - \left( -\frac{GMm}{r} \right) \quad \leftarrow \text{1 mark}$$

$$\frac{GMm}{r'} = \frac{GMm}{r} - W \quad \leftarrow \text{1 mark}$$

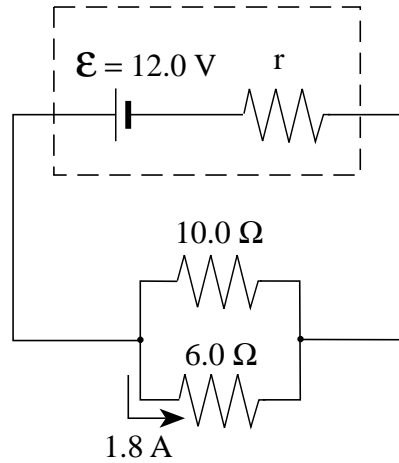
$$\frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times 1\,250}{r'} = \frac{6.67 \times 10^{-11} \times 5.98 \times 10^{24} \times 1\,250}{6.38 \times 10^6} - 2.5 \times 10^{10} \quad \leftarrow \text{1 mark}$$

$$\frac{4.99 \times 10^{17}}{r'} = 7.8 \times 10^{10} - 2.5 \times 10^{10}$$

$$\frac{4.99 \times 10^{17}}{r'} = 5.3 \times 10^{10}$$

$$r' = 9.39 \times 10^6 \text{ m} \quad \leftarrow \text{2 marks}$$

5. A battery with an emf of 12.0 V and an internal resistance  $r$  is connected to a circuit as shown below.



If the current through the  $6.0 \Omega$  resistor is  $1.8 \text{ A}$ , what is the internal resistance  $r$ ? **(7 marks)**

$$V_6 = V_T = (1.8)(6.0) = 10.8 \text{ V} \quad \leftarrow \text{2 marks}$$

$$I_{10} = \frac{V_{10}}{R} = \frac{10.8}{10} = 1.08 \text{ A} \quad \leftarrow \text{1 mark}$$

$$I_T = 1.8 + 1.08 = 2.88 \text{ A} \quad \leftarrow \text{1 mark}$$

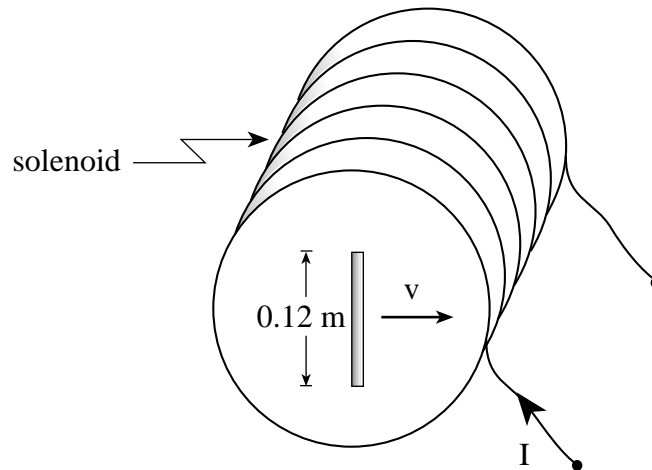
$$V_T = \mathcal{E} - Ir \quad \leftarrow \text{1 mark}$$

$$10.8 = 12 - (2.88)r$$

$$r = 0.42 \Omega \quad \leftarrow \text{2 marks}$$



6. A solenoid of length 0.85 m has a radius of 0.10 m . A current of 25 A flows through its 7 600 turns. Within this solenoid, a 0.12 m wire moves as shown and develops an emf of 0.055 V across its ends.



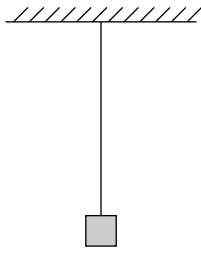
With what speed does the wire move perpendicular to the solenoid's magnetic field? **(7 marks)**

$$\mathcal{E} = Bl_w v \quad \leftarrow \text{2 marks}$$

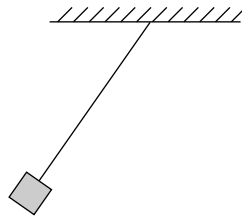
$$v = \frac{\mathcal{E}}{Bl_w} = \frac{\mathcal{E}}{\left(\mu_0 \frac{N}{l_s} I\right) l_w} = \frac{0.055}{(4\pi \times 10^{-7}) \left(\frac{7\,600}{0.85}\right) (25)(0.12)} = 1.6 \text{ m/s} \quad \leftarrow \text{2 marks}$$

↑  
**3 marks**

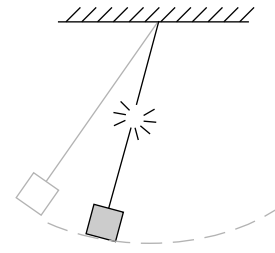
7. A heavy object initially hangs from a piece of thread. When the object is drawn aside and released, the thread is observed to break before the object reaches its lowest point. Using principles of physics, explain why the thread was strong enough to initially suspend the mass but not strong enough to support it when swinging. **(4 marks)**



Object suspended  
in equilibrium



Object released



Thread breaks

Originally the thread exerts a force equal to the object's weight. As it swings, however, the object travels along a circular arc, so the thread must exert a centripetal force also. The thread is unable to produce this larger force and therefore breaks.

**PART C: ELECTED TOPICS**

**SECTION I: Quantum Mechanics**

1. What is the momentum of a photon whose frequency is  $5.89 \times 10^{15}$  Hz ? **(3 marks)**

$$c = f \lambda$$

$$\lambda = \frac{c}{f} = \frac{3.0 \times 10^8}{5.89 \times 10^{15}}$$
$$= 5.09 \times 10^{-8} \text{ m} \quad \leftarrow \text{1 mark}$$

$$p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{5.09 \times 10^{-8}} \quad \leftarrow \text{1 mark}$$

$$p = 1.3 \times 10^{-26} \text{ kg} \cdot \text{m/s} \quad \leftarrow \text{1 mark}$$

2. The electron of a singly ionized helium ( $\text{He}^+$ ) atom makes a transition from the first excited state ( $n = 2$ ) to the fourth excited state ( $n = 5$ ).  $\text{He}^+$  has two protons and two neutrons in its nucleus. How much energy was absorbed by this helium ion? **(4 marks)**

$$E_2 = \frac{-13.6(2^2)}{2^2} = -13.6 \text{ eV} \quad \leftarrow \text{1 mark}$$

$$E_5 = \frac{(-13.6)(2^2)}{5^2} = -2.18 \text{ eV} \quad \leftarrow \text{1 mark}$$

$$\Delta E = E_5 - E_2 = (-2.18) - (-13.6)$$
$$= 11.4 \text{ eV} \quad \leftarrow \text{2 marks}$$

3. A metal surface has a work function of 2.33 eV. What wavelength of light will cause this surface to emit electrons with a maximum speed of  $1.44 \times 10^6$  m/s? **(5 marks)**

$$E_k = \frac{1}{2}mv^2 = \frac{1}{2}(9.11 \times 10^{-31})(1.44 \times 10^6)^2$$
$$= 9.45 \times 10^{-19} \text{ J} = 5.89 \text{ eV} \quad \leftarrow \text{2 marks}$$

$$E_k = hf - W_0$$

$$5.89 = hf - 2.33$$

$$8.23 = hf \quad \leftarrow \text{2 marks}$$

$$8.23 = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{8.23} = \frac{(4.14 \times 10^{-15})(3.0 \times 10^8)}{8.23} \quad \leftarrow \text{1 mark}$$

$$\lambda = 1.51 \times 10^{-7} \text{ m}$$

**END OF SECTION I: Quantum Mechanics**

## SECTION II: Fluid Theory

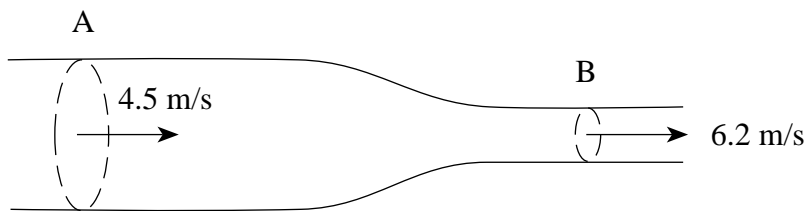
1. At what temperature will the average translational kinetic energy of a gas molecule be  $5.8 \times 10^{-21}$  J? **(3 marks)**

$$E_k = \frac{3}{2} kT \quad \leftarrow 1 \text{ mark}$$

$$\begin{aligned} T &= \frac{2E_k}{3k} \\ &= \frac{2(5.8 \times 10^{-21})}{3(1.38 \times 10^{-23})} \end{aligned}$$

$$T = 280 \text{ K} \quad \leftarrow 2 \text{ marks}$$

2. Water in a pipe has a speed of 4.5 m/s at **A** and a speed of 6.2 m/s at **B** as shown below.



- If the cross-sectional area of the pipe at **A** is  $3.0 \times 10^{-3} \text{ m}^2$ , what is the area of the pipe at **B**? **(4 marks)**

$$Av = \text{constant}$$

$$A_A v_A = A_B v_B \quad \leftarrow 2 \text{ marks}$$

$$\begin{aligned} A_B &= \frac{A_A v_A}{v_B} \\ &= \frac{(3.0 \times 10^{-3})(4.5)}{6.2} \end{aligned}$$

$$= 2.2 \times 10^{-3} \text{ m}^2 \quad \leftarrow 2 \text{ marks}$$

3. An airplane of mass 950 kg has wings with a total surface area of  $12 \text{ m}^2$ . If air passes under the wings at 55 m/s, how fast must the air pass over the wings if the lift force produced is to balance the weight of the airplane? **(5 marks)**

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

$$\Delta P = 7.76 \times 10^2 \text{ Pa} \quad \leftarrow \text{2 marks}$$

$$\frac{1}{2} \rho v_1^2 - \frac{1}{2} \rho v_2^2 = \Delta P \quad \leftarrow \text{1 mark}$$

$$\frac{1}{2} (1.29) (v_1^2) - \frac{1}{2} (1.29) (55^2) = 7.76 \times 10^2 \quad \leftarrow \text{1 mark}$$

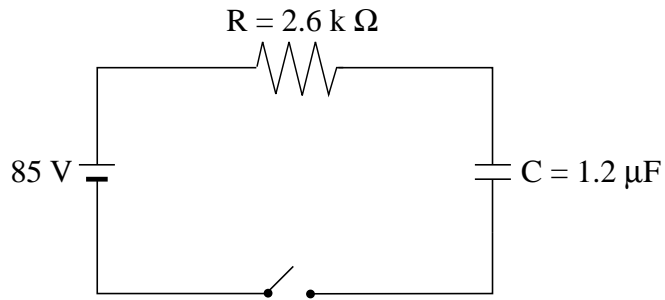
$$\frac{1}{2} (1.29) v_1^2 = 2.73 \times 10^3$$

$$v_1 = 65 \text{ m/s} \quad \leftarrow \text{1 mark}$$

**END OF SECTION II: Fluid Theory**

### SECTION III: AC Circuitry and Electronics

1. The diagram below shows a circuit used to charge a capacitor.



When the switch has been closed for several minutes, what will be the charge on the capacitor?

**(3 marks)**

$$Q = CV \quad \leftarrow \text{1 mark}$$

$$= (1.2 \times 10^{-6})(85)$$

$$= 1.02 \times 10^{-4} \text{C} \quad \leftarrow \text{2 marks}$$

2. An amplifier has a gain of 30 without feedback and a gain of 12 with feedback. Calculate the feedback ratio.

**(4 marks)**

$$A_f = \frac{A}{1 - \beta A} \quad \leftarrow \text{1 mark}$$

$$12 = \frac{30}{1 - \beta(30)} \quad \leftarrow \text{1 mark}$$

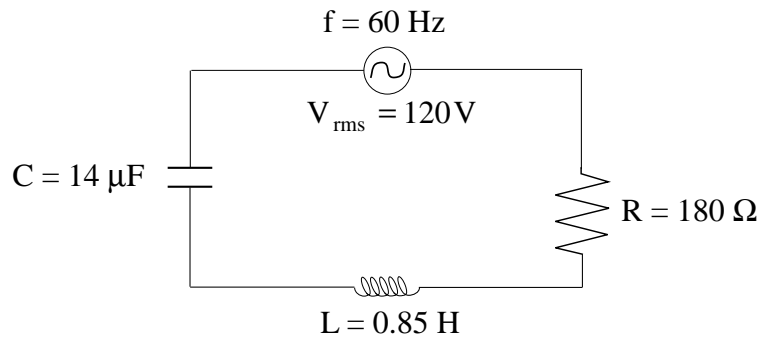
$$12 - 360\beta = 30$$

$$-360\beta = 18$$

$$\beta = -0.050 \quad \leftarrow \text{2 marks}$$

3. What is the rms voltage across the capacitor in the diagram shown below?

**(5 marks)**



$$X_L = 2\pi fL = 3.2 \times 10^2 \Omega \quad \leftarrow \text{1 mark}$$

$$X_C = \frac{1}{2\pi fC} = 1.89 \times 10^2 \Omega \quad \leftarrow \text{1 mark}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = 2.22 \times 10^2 \Omega \quad \leftarrow \text{1 mark}$$

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{Z} = \frac{120}{222} = 0.54 \text{ A} \quad \leftarrow \text{1 mark}$$

$$V_{\text{rms}} = I_{\text{rms}} X_C$$

$$= 102 \text{ V} \quad \leftarrow \text{1 mark}$$

**END OF SECTION III: AC Circuitry and Electronics**

**END OF KEY**