Applications of Physics 12

June 2001 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Transformers	A, B, C
2.	Momentum	D, E
3.	Energy Conversion	F
4.	Transducers	G, H
5.	Waves and Vibrations	I, J
6.	Electricity and Magnetism	K, L, M

PART A: Multiple Choice

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	C	K	2	1	A5	16.	C	U	2	5	I4
2.	D	U	2	1	A3	17.	C	U	2	5	I6
3.	D	U	2	1	B2	18.	A	U	2	5	I13
4.	C	H	2	1	B3, 4	19.	B	U	2	5	J11
5.	B	K	2	2	D3	20.	A	K	2	6	K5
6.	B	U	2	2	D4	21.	B	U	2	6	K5
7.	B	U	2	2	E2	22.	D	H	2	6	K6
8.	B	K	2	2	E2	23.	C	U	2	6	K8
9.	D	U	2	3	F5	24.	B	U	2	6	K10
10.	D	K	2	4	G8	25.	A	K	2	6	L3
11.	A	U	2	4	G5, 11	26.	D	U	2	6	L7
12.	D	H	2	4	G8	27.	A	H	2	6	L6
13.	A	U	2	4	H8, 7	28.	B	U	2	6	M4, 5
14.	A	H	2	4	H8	29.	B	K	2	6	M7
15.	D	K	2	5	I2	30.	C	U	2	6	M8

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	5	1	A2, 4
2.	2	U	5	1	C6, 5
3.	3	H	5	2	D3
4.	4	U	6	2	E2, 4
5.	5	U	4	3	F4
6.	6	U	5	4	G6
7.	7	U	5	4, 6	H5, K2
8.	8	U	5	5	I9
9.	9	H	5	5	I1
10.	10	U	6	5	J5, 9
11.	11	U	5	6	K8
12.	12	U	4	6	L6

Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (12 questions)
EXAMINATION TOTAL = 120 marks

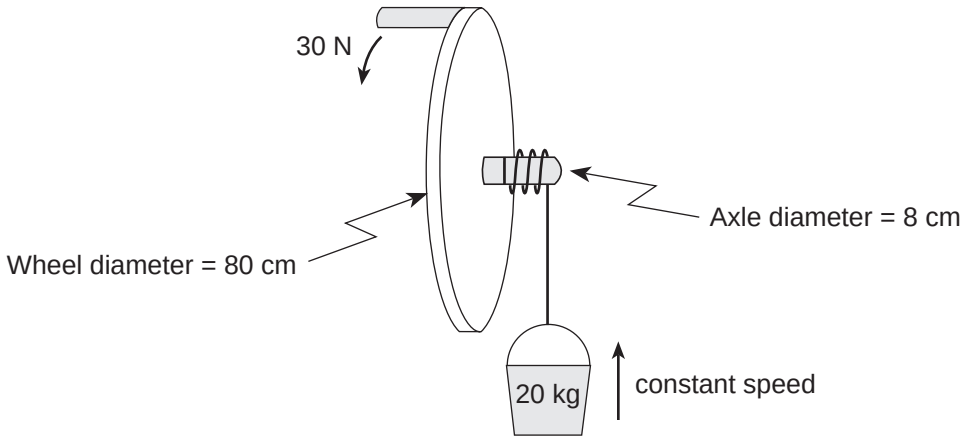
LEGEND:

Q = Question Number
B = Score Box Number
C = Cognitive Level
CO = Curriculum Organizer
K = Keyed Response
S = Score
PLO = Prescribed Learning Outcome

1. a) Explain the difference between ideal mechanical advantage (IMA) and actual mechanical advantage (AMA). **(2 marks)**

Ideal mechanical advantage is the number of times a machine could multiply its input force if there were no energy losses (due, for instance, to friction). Actual mechanical advantage is the number of times the input force is actually multiplied by the machine.

b) Determine the ideal mechanical advantage and the actual mechanical advantage for the situation shown below. **(3 marks)**



$$\text{IMA} = \frac{\text{input distance}}{\text{output distance}} = \frac{\pi(80\text{ cm})}{\pi(8\text{ cm})} = 10 \qquad \leftarrow \mathbf{1\,\tfrac{1}{2}\ marks}$$

$$\text{AMA} = \frac{\text{Load F}}{\text{Effort F}} = \frac{20\text{ kg} \times 9.8\text{ N/kg}}{30\text{ N}} = 6.5 \qquad \leftarrow \mathbf{1\,\tfrac{1}{2}\ marks}$$

2. An ideal transformer is rated at 10 000 watts. The ratio of secondary to primary turns is 0.10. The primary voltage is 2 200 V. If the transformer is operated at its rated capacity,

a) determine the secondary voltage. **(3 marks)**

$$\frac{V_{out}}{V_{in}} = \frac{N_{out}}{N_{in}}$$

$$\frac{V_{out}}{2\,200} = 0.10$$

$$V_{out} = 220 \text{ V}$$

b) determine the primary current. **(2 marks)**

$$P = IV = 10\,000 \text{ watts}$$

$$I = \frac{10\,000}{2\,200}$$

$$= 4.5 \text{ A}$$

3. An automatic rifle fires 30 g bullets with a muzzle velocity of 600 m/s. A person holding the rifle can exert a force of 220 N.

What is the maximum number of bullets per second that can be fired by this weapon? **(5 marks)**

$m = 30\text{ g} = 0.030\text{ kg}$ ← **1 mark**

$M = \#\ of\ bullets \times mass/bullet$ ← **1 mark**

$F\Delta t = M\Delta v$

$F\Delta t = nm\Delta v$ } ← **1 mark**

$\frac{n}{\Delta t} = \frac{F}{m\Delta v} = \frac{220}{0.030(600)} = 12.2$ ← **2 marks**

$\therefore \max \frac{\#}{s} = 12$

4. A wheel of moment of inertia $20\ \text{kg}\cdot\text{m}^2$ is rotated from rest by a constant torque and gains 360 J in 10 s.

a) Calculate the angular velocity after 10 s. **(3 marks)**

$$E_k = \tfrac{1}{2} I\omega^2 = 360\ \text{J}$$

$$10\cdot\omega^2 = 360$$

$$\omega = 6.0\ \text{rad/s}$$

b) Calculate the torque. **(3 marks)**

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{6}{10} = 0.60\ \text{rad/s}^2$$

$$\tau = I\alpha = 20(0.6) = 12\ \text{N}\cdot\text{m}$$

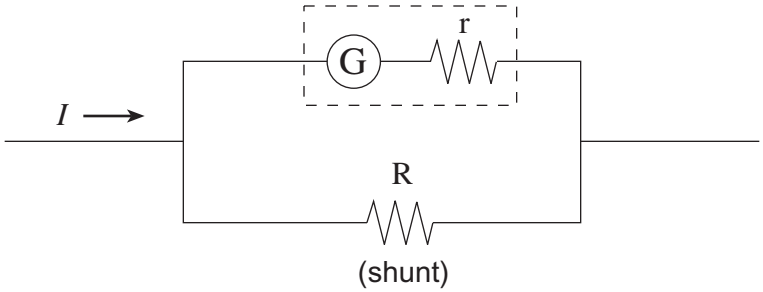
5. Describe the energy conversions that occur in a moving coil meter (ammeter) that is being used to measure current in a circuit. **(4 marks)**

Electric current flowing in the coils of the meter produces a magnetic field which interacts with the permanent magnetic field. The interaction causes a force on the coil which moves it through a distance doing work on the needle. The movement of the coil is restricted by a spring and the work is converted into stored elastic energy. (3 marks) While current flows through the coils there will be electrical energy converted into thermal energy due to the resistance of the coils. (1 mark)

6. Explain how a piezoelectric accelerometer indicates changes in motion. **(5 marks)**

A mass is in contact with a piezoelectric device or crystal. (1 mark) When a varying motion is applied to the mass (1 mark) and thus to the accelerometer (1 mark), the crystal experiences a varying force (1 mark), causing a varying electrical (voltage) output. (1 mark)

7. a) Draw a circuit diagram showing how a galvanometer may be modified for use as a practical ammeter. **(2 marks)**



b) Explain the modification(s) made in part a). **(3 marks)**

The galvanometer can only measure very small currents; therefore, it needs to be adapted to measure larger currents. A resistor which is small relative to the internal resistance of the galvanometer, called a "shunt" resistor, is placed in parallel with the galvanometer. ($\frac{1}{2}$ mark) Since it is smaller, the shunt resistor will draw away more of the current ($\frac{1}{2}$ mark), allowing a greater current to pass through the "ammeter" than could pass through the galvanometer alone. (2 marks)

8. Explain why some concert halls can have acoustic "dead spots". **(5 marks)**

Interference can cause standing waves to be established in a concert hall when sound waves are reflected causing interference. (1 mark) Destructive interference produces nodes (dead spots) where a crest meets a trough. (2 marks)

9. Describe **two** practical methods which could be used to measure the speed of sound. Include the major source of error for one of the methods.

a) Method 1: **(2 marks)**

Echo — measure distance, time
$v = d/t$

b) Method 2: **(2 marks)**

Resonance in a tube — standing waves.

c) Source of error for method ____ : **(1 mark)**

Method 1: accurate measurement of time
Method 2: accurate measurement of distance between nodes

10. a) What is the speed of light in flint glass which has an index of refraction of 1.65? **(3 marks)**

$n = \frac{c}{v}$ ← **1 mark**

$v = \frac{c}{n} = \frac{3.0 \times 10^8}{1.65}$ ← **1 mark**

$v = 1.8 \times 10^8$ m/s ← **1 mark**

b) What is the critical angle of flint glass in air? **(3 marks)**

$n_i \sin(i) = n_r \sin(r)$ ← **1 mark**

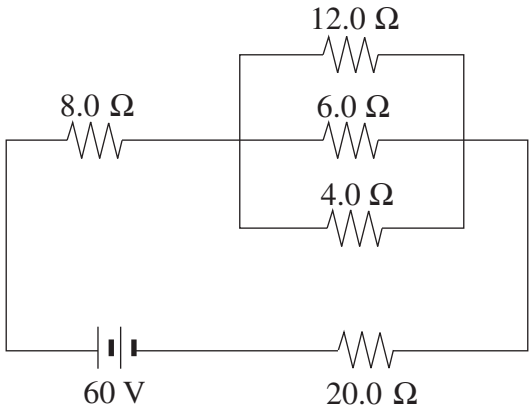
$1.65 \sin(i) = 1 \sin(90)$

$\sin(i) = \frac{1}{1.65}$

$\sin(i) = 0.606$

$i = 37.3°$ ← **1 mark**

11. Consider the following circuit:



a) Determine the equivalent resistance. **(2 marks)**

$$R_{eq} = 20 + \left(\frac{1}{\frac{1}{12} + \frac{1}{6} + \frac{1}{4}} \right) + 8$$

$$= 30\ \Omega$$

b) Determine the current through the $4.0\ \Omega$ resistor. **(3 marks)**

$$I_{total} = \frac{60\,V}{30\Omega} = 2.0\ \text{A}$$

so, $V_{20} = I \cdot R = 40\ \text{V}$ $\qquad V_8 = 16\ \text{V}$

so, $V_4 = 4.0\ \text{V}$ $\qquad$ (Kirchoff's Voltage Law)

} ← **2 marks**

$$I = \frac{V}{R} = 1.0\ \text{A}$$

← **1 mark**

12. A magnet and a similarly shaped aluminum bar are dropped down identical copper tubes. It is observed that the magnet took significantly longer to fall through its tube. Explain this occurrence using principles of physics. **(4 marks)**

As the magnet falls through the tube it induces a current in the pipe (1 mark) to oppose the change flux in the part of the tube that the magnet is nearing/leaving, according to Lenz's Law. (1 mark) This current produces a field that slows down (2 marks).

END OF KEY