Physics 12

August 2001 Provincial Examination

ANSWER KEY / SCORING GUIDE

CURRICULUM:

	Organizers	Sub-Organizers
1.	Vector Kinematics in Two Dimensions	A, B
	and	
	Dynamics *and* Vector Dynamics	C, D
2.	Work, Energy and Power	E
	and	
	Momentum	F, G
3.	Equilibrium	H
4.	Circular Motion	I
	and	
	Gravitation	J
5.	Electrostatics	K, L
6.	Electric Circuits	M, N
7.	Electromagnetism	O, P

PART A: Multiple Choice (each question worth TWO marks)

Q	K	C	S	CO	PLO	Q	K	C	S	CO	PLO
1.	B	K	2	1	C1	16.	A	K	2	4	J3
2.	C	U	2	1	C7	17.	B	U	2	4	J9, 8
3.	A	U	2	1	D3	18.	A	U	2	4	J10
4.	C	U	2	1	C8	19.	D	K	2	5	K6, 7
5.	D	U	2	1	D5; C4	20.	D	U	2	5	K8, 6
6.	B	K	2	2	E10	21.	B	U	2	5	L5
7.	B	U	2	2	E8	22.	D	K	2	6	M9
8.	C	U	2	2	E3	23.	B	U	2	6	M5, 6
9.	D	H	2	2	E8, 5	24.	B	K	2	7	P13
10.	A	K	2	3	H10	25.	B	U	2	7	O4
11.	C	U	2	3	H3	26.	C	U	2	7	O7, 3
12.	A	U	2	3	H11	27.	A	U	2	7	P1, 5; O4
13.	B	K	2	4	I1	28.	B	U	2	7	P9
14.	D	U	2	4	I4, 3	29.	B	U	2	7	P11
15.	B	H	2	4	I4; D5	30.	C	H	2	7	O4, O5; D3

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	B8, 7
2.	2	H	9	2	F4; E7
3.	3	U	7	3	H11; D4
4.	4	U	7	4	J7
5.	5	U	7	5	L6; K8; C4
6.	6	U	7	6	M2, 5; N2, 3
7.	7	U	7	7	O6, 8
8	8	H	5	1	A10; E3
9.	9	H	4	6	M11

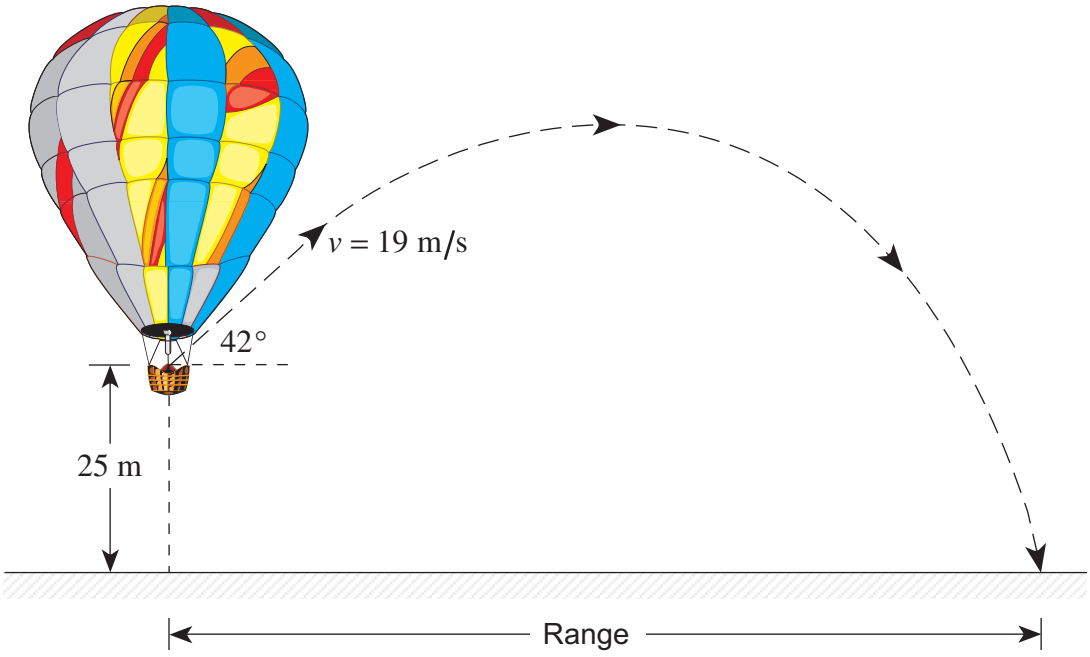
Written Response = 60 marks

Multiple Choice = 60 (30 questions)
Written Response = 60 (9 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 0.50 kg ball is thrown at 42° above the horizontal at 19 m/s from a stationary hot air balloon 25 m above the ground.



What is the range? **(7 marks)**

$v_x = 19 \times \cos 42° = 14.1$ m/s

$v_y = 19 \times \sin 42° = 12.7$ m/s

} ← **1 mark**

$t_{up} = -\dfrac{v_y}{g} = -\dfrac{12.7}{-9.8} = 1.297$ s ← **1 mark**

$d_{up} = \dfrac{1}{2} a t^2 = \dfrac{1}{2} 9.8 (1.297)^2$

$= 8.25$ m ← **1 mark**

$d_t = 25 + 8.25 = 33.25$ m ← **½ mark**

$t_d = \sqrt{\dfrac{2 \times d_t}{a}} = \sqrt{\dfrac{2 \times 33.25}{9.8}} = 2.60$ s ← **1 mark**

$t_t = t_{up} + t_d = 1.297 + 2.60 = 3.90$ s ← **½ mark**

$d_x = v_x \times t = 14.1 \times 3.90 = 55$ m (Range) ← **2 marks**

2. A rocket motor, capable of generating a $24\ \text{N}\cdot\text{s}$ impulse, is attached to a stationary frictionless 3.0 kg cart. The rocket motor is ignited.

a) What will the velocity of the cart be immediately after the rocket motor burns out? **(3 marks)**

$Impulse = m\Delta v$ ← **1 mark**

$24 = 3.0\Delta v \qquad \therefore \Delta v = 8.0\ \text{m/s}$

The final velocity of the 3.0 kg cart is 8.0 m/s. ← **2 marks**

b) What is the resulting kinetic energy of the cart? **(2 marks)**

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

$$= \frac{1}{2}\cdot 3.0\cdot (8.0)^2 \qquad \leftarrow \textbf{1 mark}$$

$$= 96\ \text{J} \qquad \leftarrow \textbf{1 mark}$$

c) A frictionless cart of larger mass will end up with less kinetic energy when powered by an identical rocket motor. Using principles of physics, explain this result. **(4 marks)**

2 marks → Work is done on both carts. However, the lighter cart is travelling faster while the force is being applied

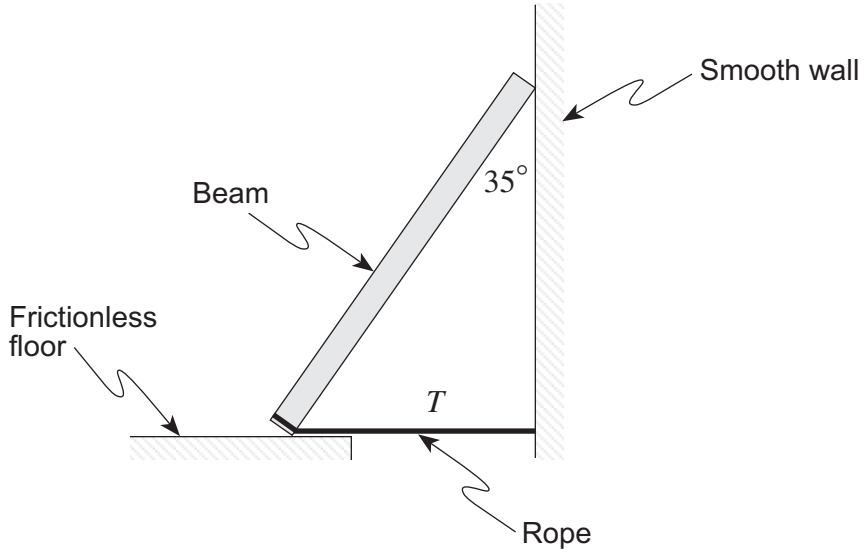
2 marks → and therefore more work is being done on it while it travels the greater distance.

OR

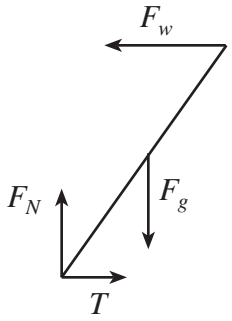
2 marks → The velocity change of each cart is inversely related to its mass. The heavier cart therefore has a smaller velocity change.

2 marks → The v^2 term will therefore dominate in the final kinetic energy.

3. A 24 kg beam of length 2.4 m leans against a smooth wall. A horizontal rope tied to the wall and the beam holds the beam on a frictionless floor as shown.



a) Draw a labelled free-body diagram for the forces acting on the beam. **(2 marks)**



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

$$\tau_{cc} = \tau_c \qquad \leftarrow \textbf{1 mark}$$

$$F_w \times \sin 55° \times 2.4 = mg \times \sin 35° \times 1.2 \qquad \leftarrow \textbf{2 marks}$$

$$F_w = \frac{24 \times 9.8 \times \sin 35° \times 1.2}{\sin 55° \times 2.4} \qquad \leftarrow \textbf{1 mark}$$

$$\therefore T = F_w = 82 \text{ N} \qquad \leftarrow \textbf{1 mark}$$

4. A spacecraft of mass 470 kg rests on the surface of an asteroid of radius 1 400 m and mass 2.0×10^{12} kg. How much energy must be expended so that the spacecraft may rise to a height of 2 800 m above the surface of the asteroid? **(7 marks)**

$\Delta E = E_p' - E_p$ ← **2 marks**

$= \left(-G\frac{Mm}{r'}\right) - \left(-\frac{GMm}{r}\right)$ ← **2 marks**

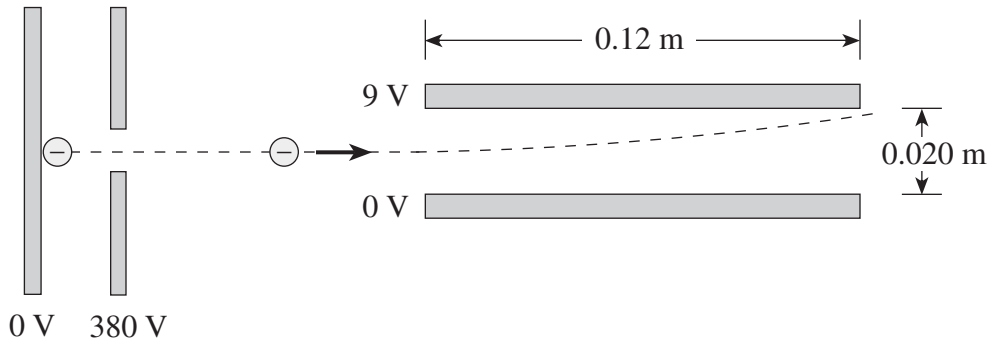
$= \left(-\frac{6.67\times10^{-11}\times2.0\times10^{12}\times470}{(1\,400+2\,800)}\right) - \left(-\frac{6.67\times10^{-11}\times2.0\times10^{12}\times470}{1\,400}\right)$ ← **2 marks**

$= (-14.9) - (-44.8)$

$= 29.9$ J

$= 30$ J ← **1 mark**

5. A beam of electrons is directed to a region between oppositely charged parallel plates as shown in the diagram below.



a) The electron beam is produced by accelerating electrons through an electric potential difference of 380 V. What is the speed of the electrons as they leave the 380 V plate? **(3 marks)**

$$\Delta E_k = \Delta E_p$$

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

$$\therefore v = \left(\frac{2QV}{m}\right)^{\frac{1}{2}}$$

$$= \left(\frac{2 \cdot 1.6\times10^{-19} \cdot 380}{9.11\times10^{-31}}\right)^{\frac{1}{2}}$$

$$= 1.2\times10^{7} \text{ m/s} \qquad \leftarrow \textbf{3 marks}$$

b) What is the electrostatic force on electrons in the region between the horizontal plates when they are connected to a 9.0 V potential difference? **(4 marks)**

$$E_{plates} = \frac{V}{d}$$

$$= \frac{9.0}{0.020}$$

$$= 4.5\times10^{2} \text{ V/m} \qquad \leftarrow \textbf{2 marks}$$

$$\therefore F_E = qE$$

$$= 1.6\times10^{-19} \cdot 4.50\times10^{2} \qquad \leftarrow \textbf{2 marks}$$

$$= 7.2\times10^{-17} \text{ N}$$

6. A 12 V battery transfers 33 C of charge to an external circuit in 7.5 s.

a) What current flows through the circuit? **(2 marks)**

$I = \frac{a}{t}$ ← **½ mark**

$= \frac{33\text{ C}}{7.5\text{ s}}$ ← **½ mark**

$= 4.4\text{ A}$ ← **1 mark**

b) What is the resistance of the circuit? **(2 marks)**

$R = \frac{V}{I}$ ← **½ mark**

$= \frac{12}{4.4}$ ← **½ mark**

$= 2.7\ \Omega$ ← **1 mark**

c) What is the power output of the battery? **(2 marks)**

$P = V \cdot I$ ← **½ mark**

$= 12(4.4)$ ← **½ mark**

$= 53\text{ W}$ ← **1 mark**

d) The external circuit is most likely to consist of

- ☑ a bulb.
- ☐ a kettle.
- ☐ a calculator.

(Check one response.) **(1 mark)**

7. An electron travelling at 7.7×10^{6} m/s enters at right angles into a uniform magnetic field. Inside the field the path of the electron has a radius of 3.5×10^{-2} m.

a) What is the magnitude of the magnetic field? **(4 marks)**

$$F_C = F_B$$

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

$$B = \frac{mv}{qR}$$

$$= \frac{\left(9.11\times10^{-31}\right)\left(7.7\times10^{6}\right)}{\left(1.6\times10^{-19}\right)\left(3.5\times10^{-2}\right)}$$

← **3 marks**

$$B = 1.3\times10^{-3}\ \text{T}$$ ← **1 mark**

b) If the magnetic field is produced at the centre of a solenoid by a current of 0.62 A, what is the number of turns per unit length of the solenoid? **(3 marks)**

$$B = \mu_0 \frac{N}{\ell} I$$

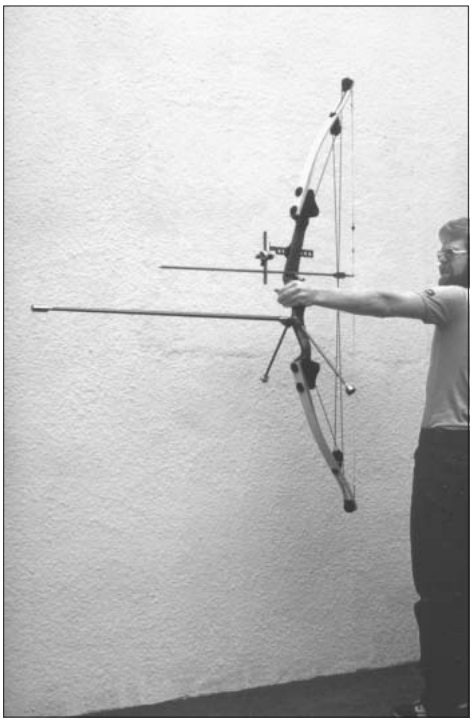
$$\frac{N}{\ell} = \frac{B}{\mu_0 I}$$

$$= \frac{1.3\times10^{-3}}{\left(4\pi\times10^{-7}\right)\left(0.62\right)}$$

← **2 marks**

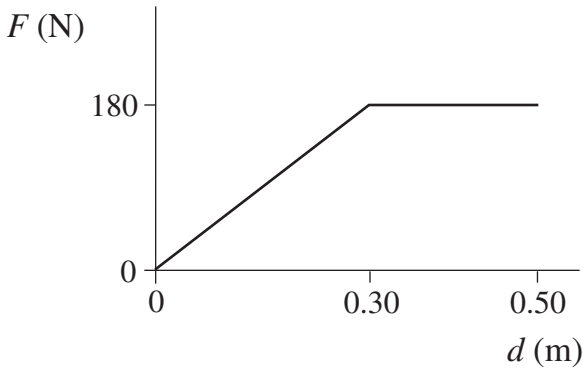
$$\frac{N}{\ell} = 1.6\times10^{3}\ \text{turns/m}$$ ← **1 mark**

8. As a compound bow was drawn back, the applied forces and displacements were recorded.



F(N)	0	31	65	84	122	160	186	180	175	184	180
d(m)	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50

a) Plot a force vs. displacement graph below. **(2 marks)**



b) How much energy was stored in this compound bow? **(3 marks)**

$Energy = W = area$

$27 + 36 \approx 63$ J

9. Two identical light bulbs, wired in parallel to a battery, are equally bright. When one of the bulbs burns out, however, the other bulb is observed to glow brighter. Using principles of physics, explain why the battery causes the remaining bulb to glow more brightly. **(4 marks)**

When one of two bulbs, wired in parallel to a battery, burns out, the resistance of the circuit increases. ← 1 mark

This results in a smaller current being delivered by the battery. ← 1 mark

The internal resistance of the battery causes the terminal voltage to increase, because $V_T = \mathcal{E} - Ir$. ← 1 mark

The bulb will now dissipate more power, because $P = \frac{V^2}{R}$. ← 1 mark (not in isolation)

If the number of paths for current is reduced to one, the current increases in the remaining path. ← 1 mark

← Any 4 for 4 marks

END OF KEY