Physics 12

January 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.	C	K	2	1	A7	16.	D	U	2	4	I4
2.	C	U	2	1	B2	17.	B	U	2	4	I4; D5
3.	A	U	2	1	B4, 5	18.	D	K	2	4	J5, 6
4.	D	K	2	1	D4	19.	C	H	2	4	I4; D5
5.	B	U	2	1	C4, 7	20.	B	K	2	5	L1
6.	D	U	2	1	D6; C4	21.	A	U	2	5	K3
7.	C	U	2	2	E10	22.	A	U	2	5	K8
8.	C	K	2	2	F2; E4; A1	23.	D	U	2	6	M6
9.	C	U	2	2	F6, 7; E7	24.	D	U	2	6	M5; N2
10.	C	U	2	2	G3	25.	B	K	2	7	O2
11.	C	H	2	2	F1; A10	26.	D	U	2	7	O4
12.	B	K	2	3	H7	27.	B	U	2	7	O5
13.	B	U	2	3	H5	28.	A	U	2	7	P4, 6; O3
14.	**DELETED**					29.	B	U	2	7	P9
15.	A	K	2	4	I3	30.	A	U	2	7	P2, 3, 5

Multiple Choice = 60 marks

PART B: Written Response

Q	B	C	S	CO	PLO
1.	1	U	7	1	C4, 8; D4
2.	2	U	7	2	E7, 8; F7
3.	3	U	7	3	H3; C8
4.	4	U	7	4	J3; D5
5.	5	U	7	5	K5
6.	6	U	7	6	N2; M6, 5
7.	7	H	9	7	O4, 6; I1, 4
8	8	H	5	1	A10; F4
9.	9	H	4	4	J8

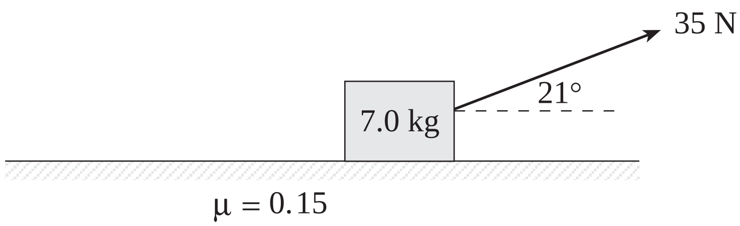
Written Response = 60 marks

Multiple Choice	=	60 (30 questions)
Written Response	=	60 (9 questions)
EXAMINATION TOTAL	**=**	**120 marks**

LEGEND:

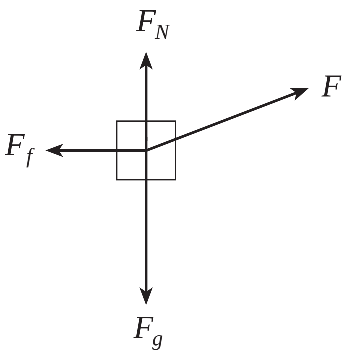
Q = Question Number | **B** = Score Box Number | **C** = Cognitive Level
CO = Curriculum Organizer | **K** = Keyed Response | **S** = Score
PLO = Prescribed Learning Outcome

1. A 35 N force applied at $21°$ to the horizontal is used to pull a mass as shown.



The coefficient of friction between the floor and the mass is 0.15.

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



← **½ mark for each vector**

b) What is the acceleration of the mass? **(5 marks)**

$$a = \frac{F_{net}}{m}$$ ← **½ mark**

$$F_{net} = F_x - F_f$$

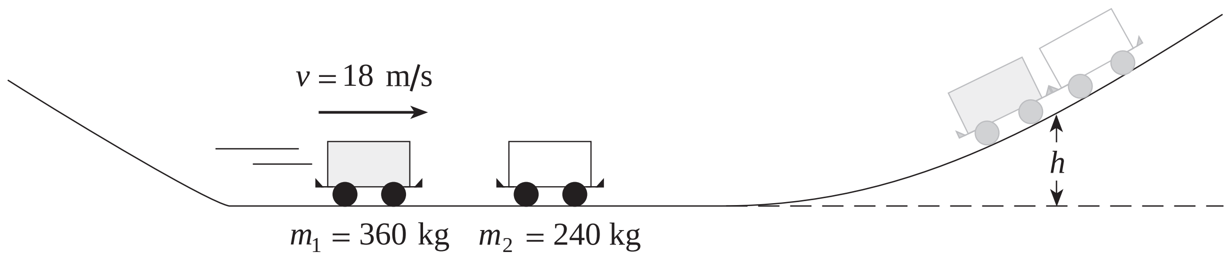
$$= 35 \times \cos 21° - 0.15(7.0 \times 9.8 - 35 \times \sin 21°)$$ ← **4 marks**

$$= 32.68 - 8.41$$

$$F_{net} = 24.3 \text{ N}$$

$$a = \frac{24.3 \text{ N}}{7.0 \text{ kg}} = 3.5 \text{ m/s}^2$$ ← **½ mark**

2. A 360 kg roller coaster car travelling at 18 m/s collides inelastically with a stationary 240 kg car on a section of horizontal track as shown in the diagram below.



To what maximum height, *h*, do the combined cars travel before rolling back down the hill? (Assume no friction.) **(7 marks)**

$$V_{combined} = \frac{m_1 v_1}{m_1 + m_2}$$

$$= \frac{360 \cdot 18}{360 + 240}$$

$$= 10.8 \text{ m/s} \qquad \leftarrow \textbf{3 marks}$$

$$E_{k\,combined} = \frac{1}{2} m v^2$$

By conservation of energy:

$$mgh = \frac{1}{2} m v^2 \qquad \leftarrow \textbf{2 marks}$$

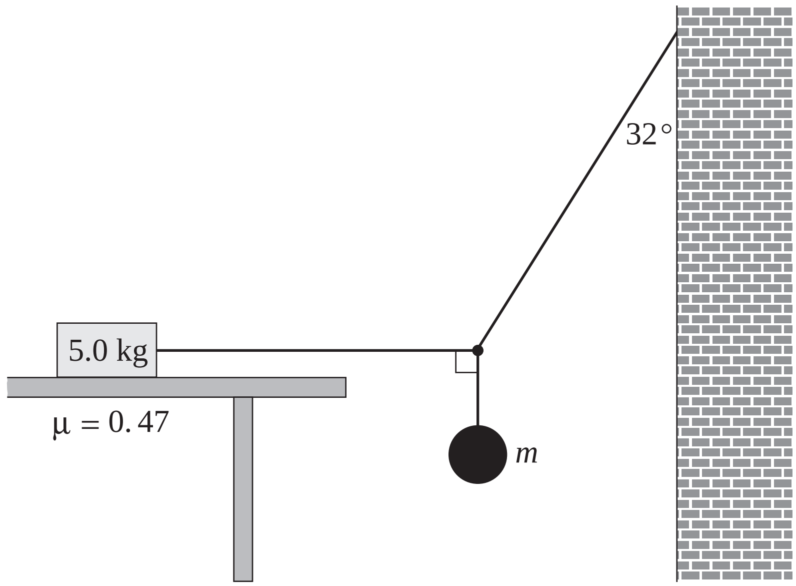
$$\therefore h = \frac{v^2}{2g}$$

$$= \frac{(10.8)^2}{2 \cdot 9.8}$$

$$= 5.95 \text{ m}$$

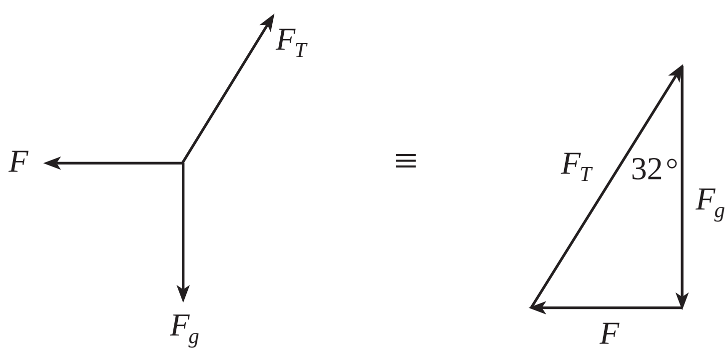
$$= 6.0 \text{ m} \qquad \leftarrow \textbf{2 marks}$$

3. An object of mass, *m*, is suspended by two cords connected to a wall and to a 5.0 kg block resting on a table as shown.



A coefficient of friction of 0.47 exists between the 5.0 kg block and the table. What is the maximum mass, *m*, that can be hung from the cords before the 5.0 kg block begins to move?

(7 marks)



$$F_f = \mu F_N$$

$$= 0.47 \times 5.0 \times 9.8$$

$$= 23 \text{ N}$$ ← **2 marks**

$$F_g = \frac{F}{\tan 32°}$$

$$mg = \frac{F}{\tan 32°}$$

$$m = \frac{F}{g \times \tan 32°}$$

$$m = \frac{23}{9.80 \times \tan 32°}$$

← **4 marks**

$$m = 3.8 \text{ kg}$$ ← **1 mark**

4. a) Mars has a mass of 6.37×10^{23} kg and a radius of 3.43×10^{6} m. What is the gravitational field strength on its surface? **(4 marks)**

$$g = \frac{GM}{r^2} \quad \leftarrow \textbf{2 marks}$$

$$= \frac{6.67 \times 10^{-11}\left(6.37 \times 10^{23}\right)}{\left(3.43 \times 10^{6}\right)^2} \quad \leftarrow \textbf{1 mark}$$

$$= 3.61 \text{ N/kg} \quad \leftarrow \textbf{1 mark}$$

b) What thrust force must the rocket engine of a Martian lander exert if the 87.5 kg spacecraft is to accelerate upwards at 1.20 m/s^2 as it leaves the surface of Mars? **(3 marks)**

$$F_{net} = ma \quad \leftarrow \textbf{1 mark}$$

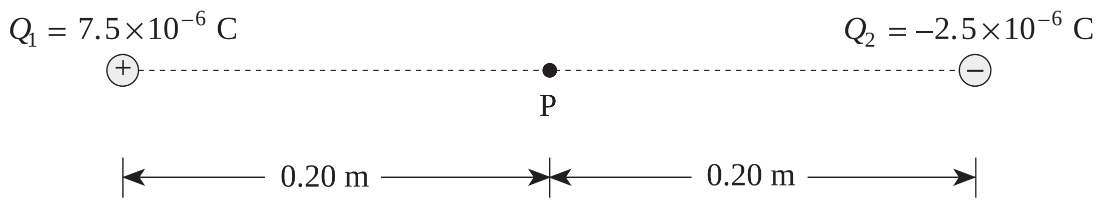
$$F_T - F_g = ma$$

$$F_T - mg = ma \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

$$F_T - 87.5(3.61) = 87.5(1.20) \quad \leftarrow \textbf{1 mark}$$

$$F_T = 421 \text{ N} \quad \leftarrow \tfrac{1}{2}\textbf{ mark}$$

5. Electric charges are arranged as shown in the diagram below.



What is the electric field (magnitude and direction) at point P midway between the charges?

(7 marks)

$$E_1 = \frac{kQ_1}{r_1^2}$$
$$= \frac{9.0 \times 10^9 \cdot 7.5 \times 10^{-6}}{(0.20)^2}$$
$$= 1.69 \times 10^6 \text{ N/C (right)}$$ ← **1 ½ marks**

$$E_2 = \frac{kQ_2}{r_2^2}$$
$$= \frac{9.0 \times 10^9 \cdot 2.5 \times 10^{-6}}{(0.20)^2}$$
$$= 5.63 \times 10^5 \text{ N/C (right)}$$ ← **1 ½ marks**

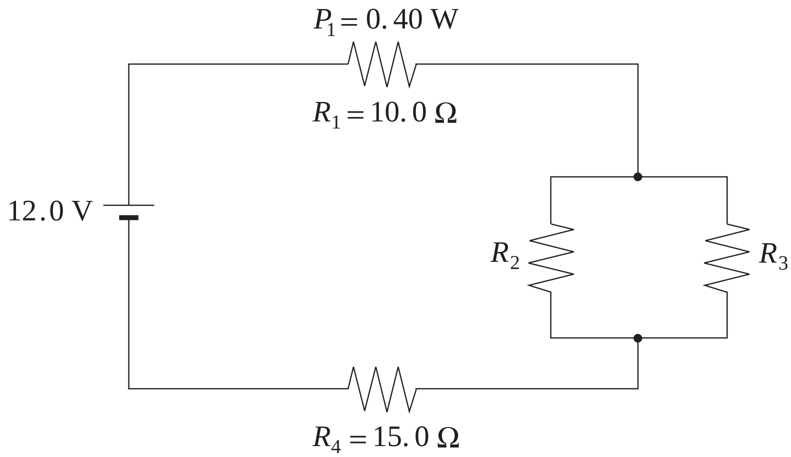
$$E_T = E_1 + E_2$$ ← **2 marks**

$$= 1.69 \times 10^6 \text{ N/C} + 5.63 \times 10^5 \text{ N/C}$$

$$= 2.25 \times 10^6 \text{ N/C (right)}$$

$$= 2.3 \times 10^6 \text{ N/C (right)}$$ ← **2 marks**

6. In the circuit below, resistor R_1 dissipates $0.40\ \text{W}$. Resistors R_2 and R_3 are identical.



What is the resistance of R_2? **(7 marks)**

Key:

$$P = I^2R$$
$$P_1 = I^2R_1$$
$$I = \left(\frac{P_1}{R_1}\right)^{\frac{1}{2}}$$
$$= \left(\frac{0.40}{10}\right)^{\frac{1}{2}}$$
$$= 0.20\ \text{A}$$

$\leftarrow$ **2 marks**

$$V_1 = IR$$
$$= 0.2(10)$$
$$= 2\ \text{V}$$

$\leftarrow$ **1 mark**

$$V_4 = IR$$
$$= 0.2(15)$$
$$= 3\ \text{V}$$

$\leftarrow$ **1 mark**

$$V_3 = V_4 = 12 - V_1 - V_4$$
$$= 7\ \text{V}$$

$\leftarrow$ **1 mark**

$$I_2 = I_3$$

$\leftarrow$ **1 mark**

$$V_3 = I_3R_3$$
$$7 = 0.1\ R_2$$
$$R_2 = 70\ \Omega$$

$\leftarrow$ **1 mark**

Alternate Key:

$$P = I^2 \cdot R$$

$$P_1 = I^2 \cdot R_1$$

$$\therefore I = \left(\frac{P_1}{R_1}\right)^{\frac{1}{2}}$$

$$= \left(\frac{0.40}{10.0}\right)^{\frac{1}{2}}$$

$$= 0.20 \text{ A}$$ ← **2 marks**

$$\therefore R_{circuit} = \frac{V}{I}$$

$$= \frac{12.0}{0.20}$$

$$= 60.0\ \Omega$$ ← **2 marks**

$$\therefore R_{||} = 60.0\ \Omega - (10.0\ \Omega + 15.0\ \Omega)$$

$$= 35.0\ \Omega$$ ← **2 marks**

$$\therefore R_2 = R_3 = 2 \cdot 35.0\ \Omega$$

$$= 70.0\ \Omega$$ ← **1 mark**

7. a) A proton moves with a speed of 3.6×10^{5} m/s at right angles to a uniform 5.0×10^{-5} T magnetic field. What is the radius of curvature for the motion of the proton? **(5 marks)**

$F_c = \dfrac{mv^2}{R}$ ← **1 mark**

$F_B = qvB$ ← **1 mark**

$F_c = F_B$ ← **1 mark**

$R = \dfrac{mv}{Bq} = \dfrac{(1.67\times10^{-27})(3.6\times10^{5})}{(5.0\times10^{-5})(1.6\times10^{-19})}$ ← **1 mark**

$R = 75$ m ← **1 mark**

b) Describe the path of the proton in the magnetic field and use principles of physics to explain the proton's motion. **(4 marks)**

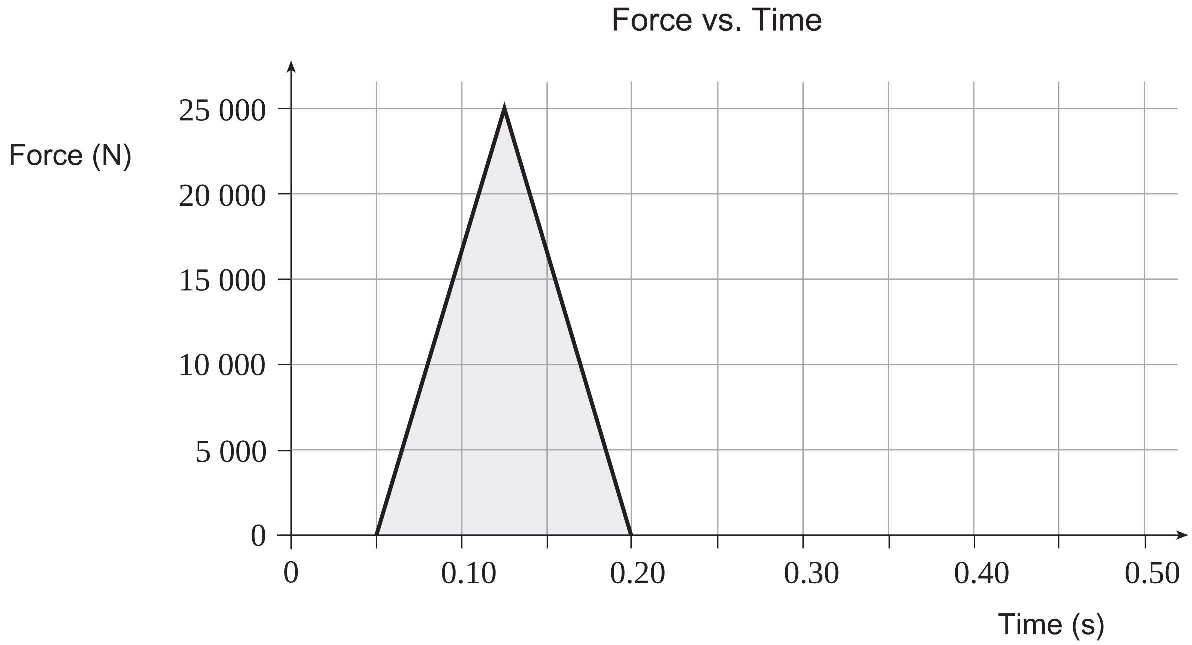
The path is circular. ← 1 mark

Moving charge in magnetic field produces a magnetic force. ← 1 mark

Force ⊥ velocity. ← 1 mark

This perpendicular force (acting on proton) produces circular motion. ← 1 mark

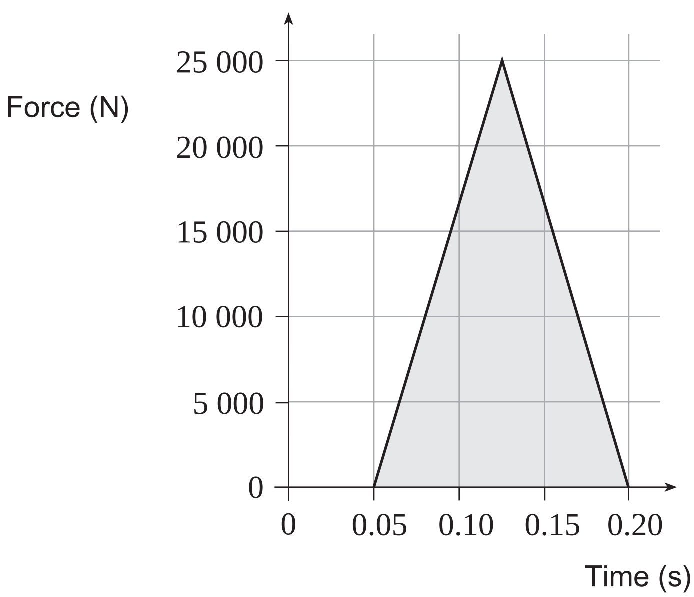
8. During a motor vehicle accident an unbelted passenger experienced a force which varied with time as shown on the graph.



a) Calculate the area of the shaded region in the graph. **(1 mark)**

two triangles: $(0.075 \times 25\,000) = 1\,875\ \mathrm{N \cdot s}$

$= 1\,900\ \mathrm{N \cdot s}$ $\leftarrow$ **1 mark**



b) What does this area represent? **(2 marks)**

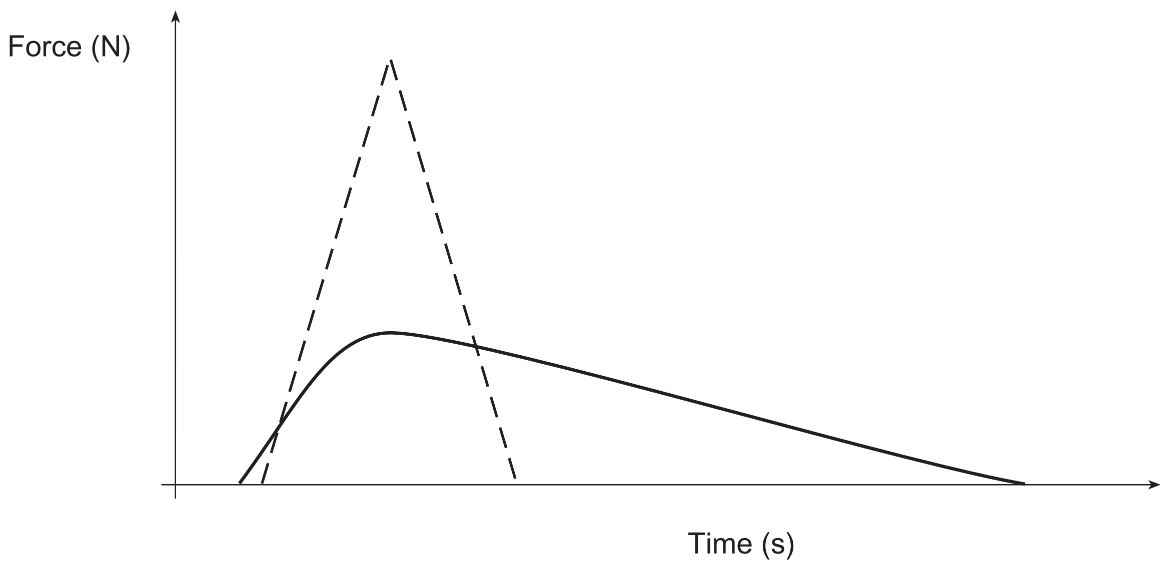
Impulse or change in momentum

c) If the passenger was wearing a seatbelt properly, the maximum force would have been one third the force experienced without the seatbelt. Sketch on the graph below how the force on the belted passenger might have varied with time. **(2 marks)**

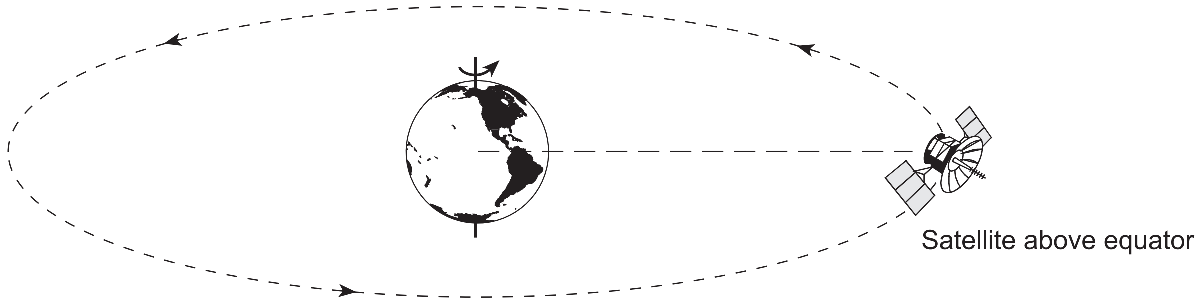
peak $\approx \frac{1}{3}(25\ 000) \approx 8\ 000$ N ← **1 mark**

(but for a longer period of time)

area should be (about) the same ← **1 mark**



9. Geostationary satellites appear to remain stationary to an observer on Earth. Such satellites are placed in orbit far above the equator.



Using principles of physics, explain why such satellites all have the same orbital radius.

(4 marks)

The period of such satellites must be 24 hours to remain stationary over one point. ← 1 mark
The centripetal force is a gravitational force. ← 2 marks
For a period of 24 hours there is one orbital radius. ← 1 mark

END OF KEY