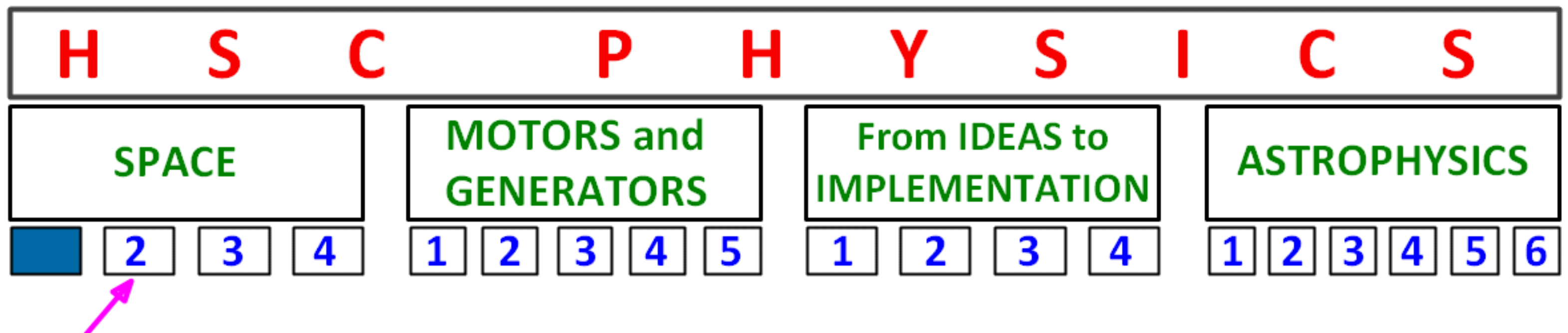


SPACE

1st Quarter; Module 1

PERIOD 14

Revision of Space 2 (so far)



SPACE 2

Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth

Students learn to:

- describe the trajectory of an object undergoing projectile motion within the Earth's gravitational field in terms of horizontal and vertical components
- describe Galileo's analysis of projectile motion
- explain the concept of escape velocity in terms of the:
 - gravitational constant
 - mass and radius of the planet
- outline Newton's concept of escape velocity
- identify why the term 'g forces' is used to explain the forces acting on an astronaut during launch
- discuss the effect of the Earth's orbital motion and its rotational motion on the launch of a rocket
- analyse the changing acceleration of a rocket during launch in terms of the:
 - Law of Conservation of Momentum
 - forces experienced by astronauts
- analyse the forces involved in uniform circular motion for a range of objects, including satellites orbiting the Earth
- compare qualitatively low Earth and geo-stationary orbits
- define the term orbital velocity and the quantitative and qualitative relationship between orbital velocity, the gravitational constant, mass of the central body, mass of the satellite and the radius of the orbit using Kepler's Law of Periods
- account for the orbital decay of satellites in low Earth orbit
- discuss issues associated with safe re-entry into the Earth's atmosphere and landing on the Earth's surface
- identify that there is an optimum angle for safe re-entry for a manned spacecraft into the Earth's atmosphere and the consequences of failing to achieve this angle

SPACE 2

Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth

Students:

- solve problems and analyse information to calculate the actual velocity of a projectile from its horizontal and vertical components using:

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2} a_y t^2$$

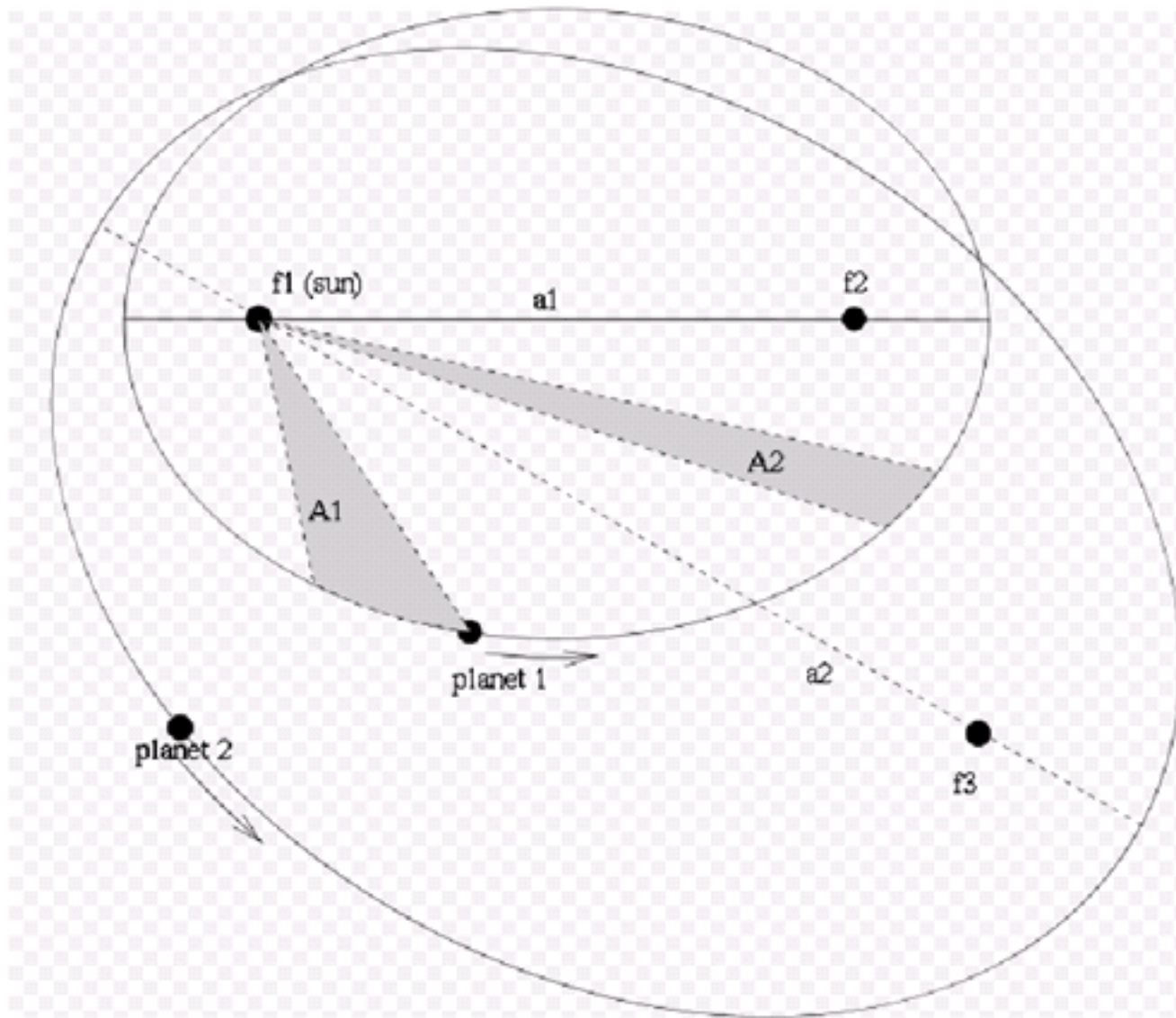
- perform a first-hand investigation, gather information and analyse data to calculate initial and final velocity, maximum height reached, range and time of flight of a projectile for a range of situations by using simulations, data loggers and computer analysis
- identify data sources, gather, analyse and present information on the contribution of one of the following to the development of space exploration: Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun
- solve problems and analyse information to calculate the centripetal force acting on a satellite undergoing uniform circular motion about the Earth using

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

- solve problems and analyse information using:

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

KEPLER'S THIRD LAW



$$\frac{T^2}{R^3} = \frac{4\pi^2}{GM}$$

$$\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$$

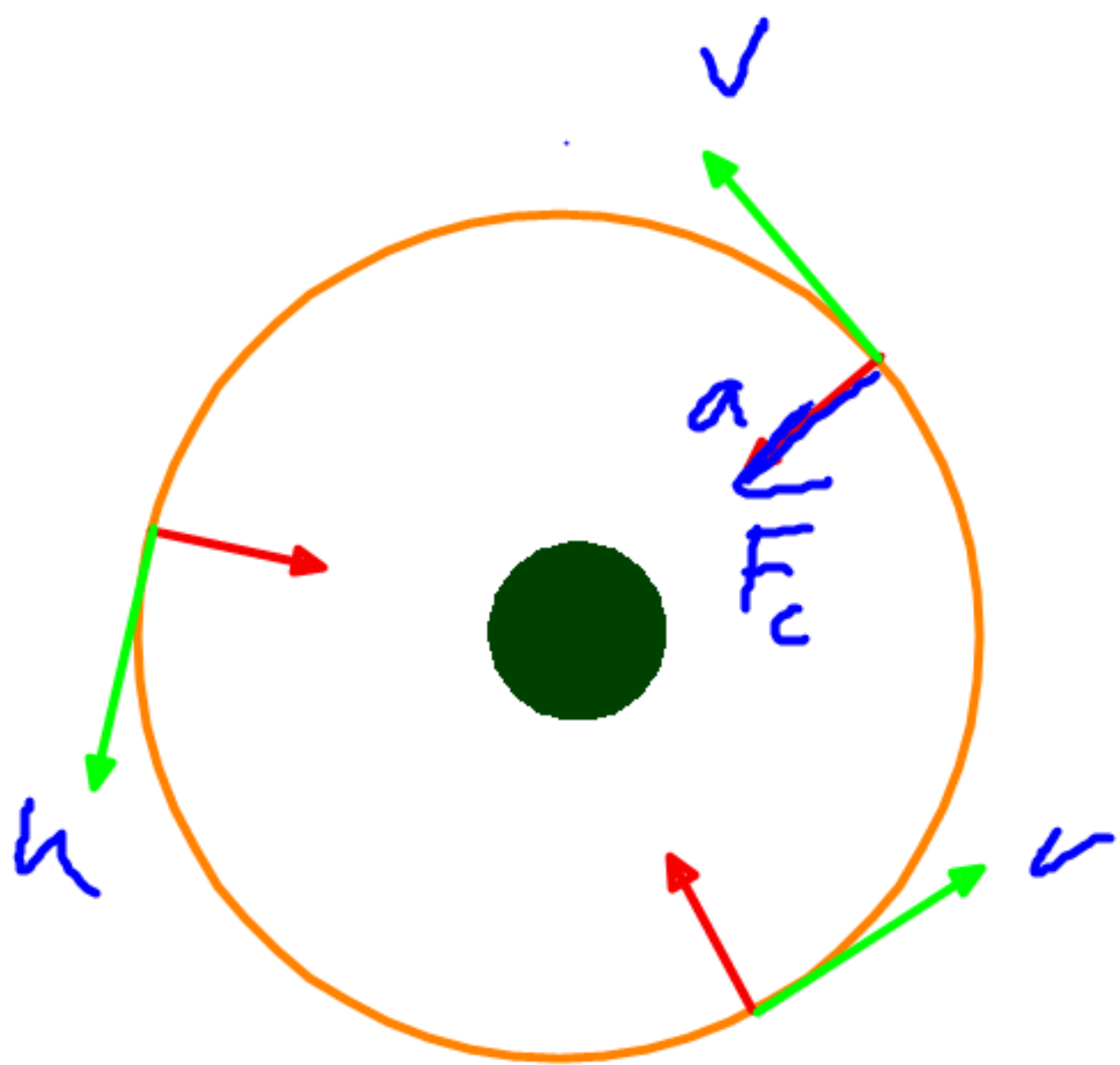
T : period of the satellite (s)

R : radius of orbit of sat. (m)

M : mass of the central body.

G : univ. gravitational constant.

CIRCULAR MOTION



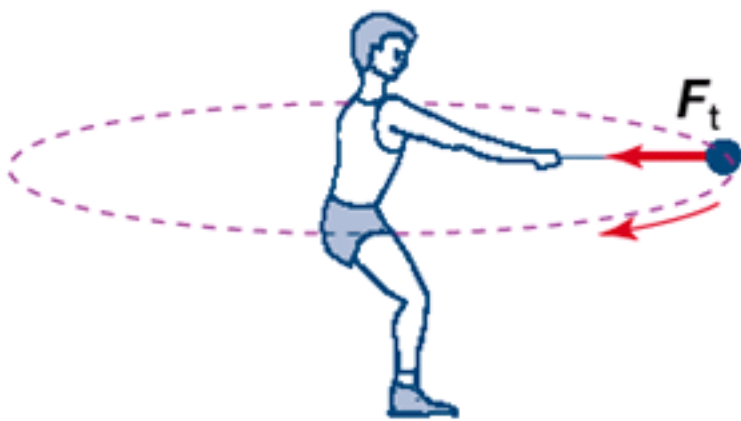
$$F_c = \frac{mv^2}{r} = m \cdot a_c$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

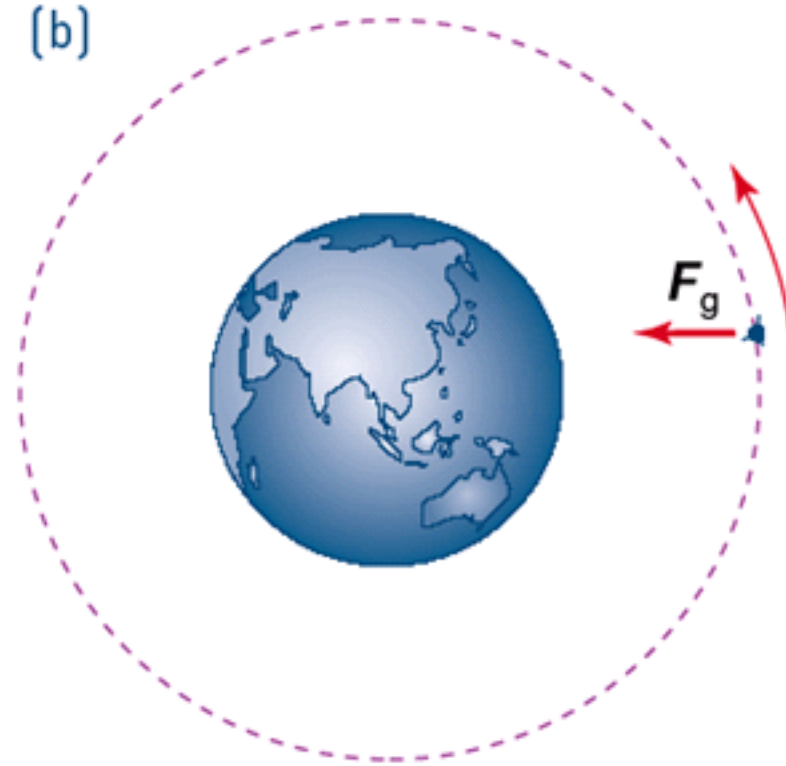
$$v = \frac{2\pi r}{T}$$

$$a_c = \frac{v^2}{r}$$

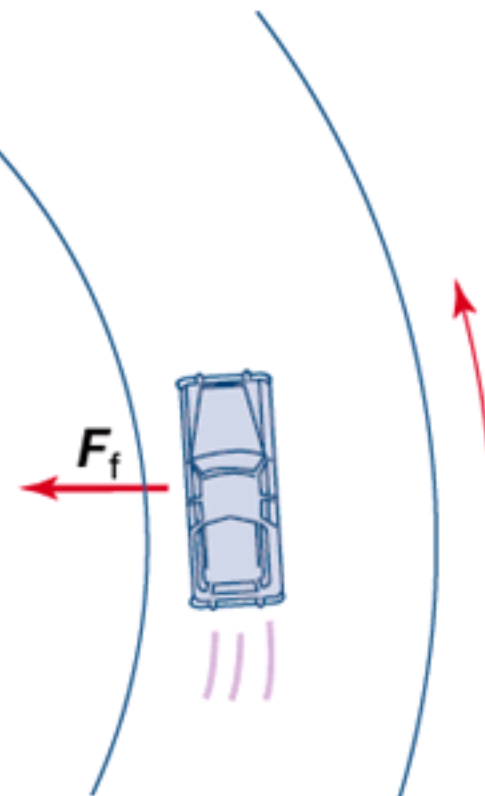
(a)



(b)



(c)



(d)

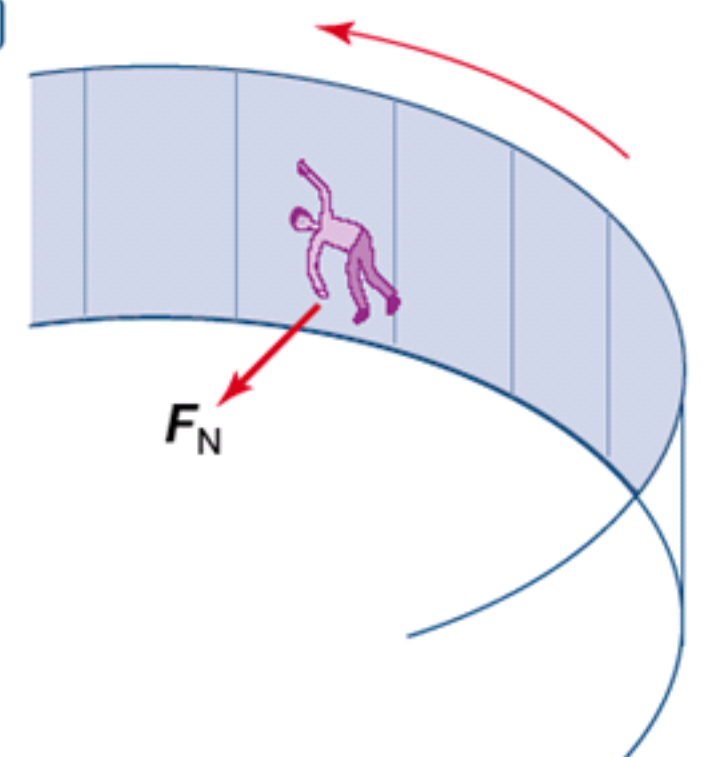


Figure 2.34 The centripetal force that produces a centripetal acceleration and hence a circular motion is provided by different real forces. (a) In a hammer throw or for any other object rotated while attached to an arm or wire, it is the tension in the arm or wire that provides the centripetal force. (b) For planets and satellites, the gravitational attraction to the central body provides the centripetal force. (c) For a car on a roundabout, it is the friction between the tyres and the road. (d) For a person in the Gravitron it is the normal force from the wall. Although the person feels that they are being pinned to the wall, the wall is in fact applying a force to their body.

2005 HSC QUESTION

Question 16 (5 marks)

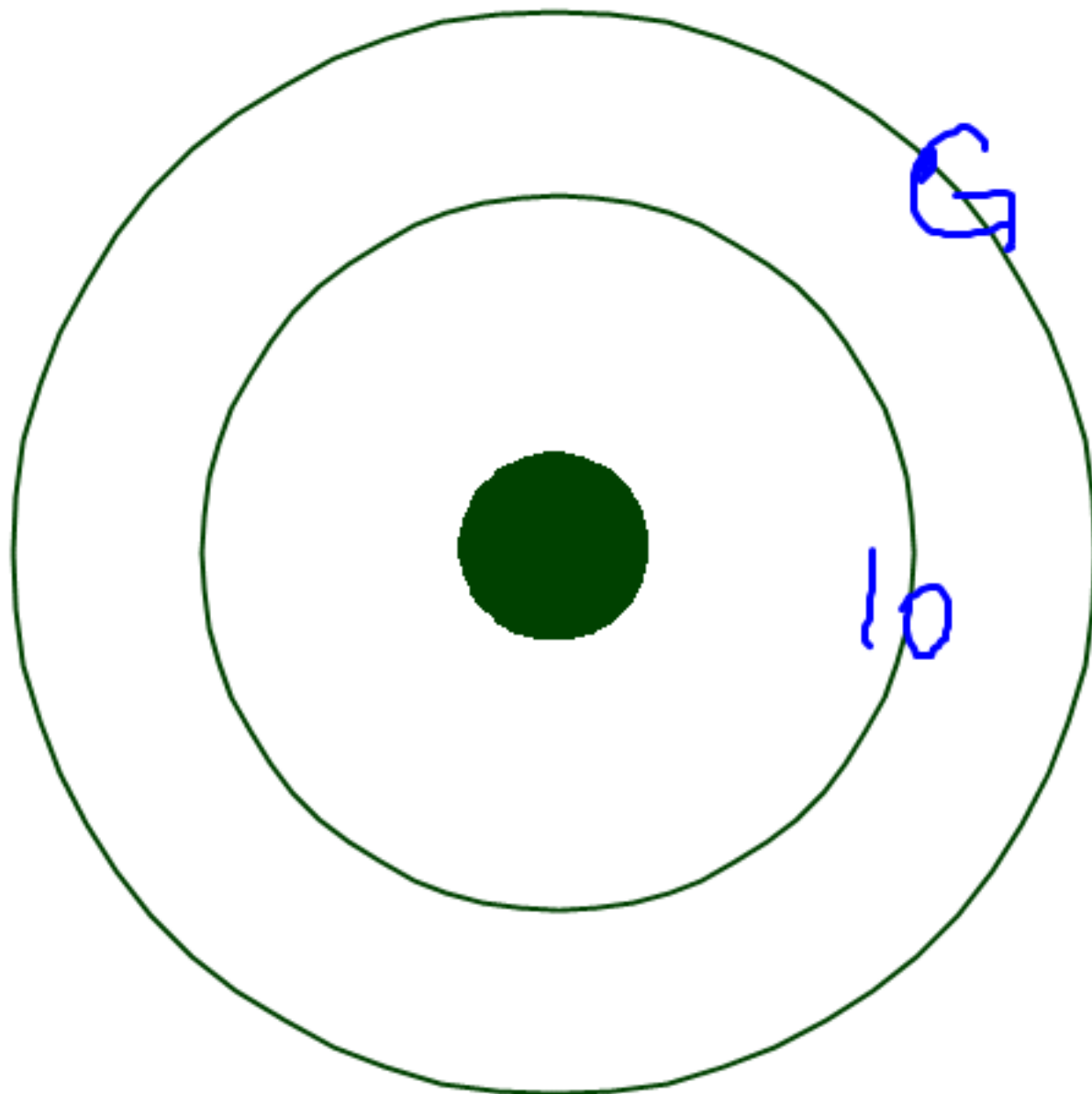
From nearest to furthest, the four satellite moons of Jupiter first observed by Galileo in the year 1610 are called Io, Europa, Ganymede and Callisto. For the first three moons, the orbital period T of each is exactly twice the period of the one orbiting immediately inside it. That is,

$$T_{\text{Europa}} = 2 \times T_{\text{Io}}$$

$$T_{\text{Ganymede}} = 2 \times T_{\text{Europa}} = 4T_{\text{Io}}$$

The mass of Jupiter is 1.90×10^{27} kg, and the orbital radius of Io is 421 600 km.

- (a) Use Kepler's Law of Periods to calculate Ganymede's orbital radius.



$$\frac{R^3}{T^2} = \frac{R^3}{T^2}$$

(Io) (G)

$$\frac{R_{\text{Io}}^3}{T^2} = \frac{R_{\text{G}}^3}{(4T)^2}$$

$$R_{\text{G}}^3 = 16 R_{\text{Io}}^3$$

$$R_{\text{G}} = \sqrt[3]{16} R_{\text{Io}}$$

$$= 2.51 \times R_{\text{Io}}$$

$$= 1\,062\,000 \text{ km}$$

Question 16 (5 marks)

From nearest to furthest, the four satellite moons of Jupiter first observed by Galileo in the year 1610 are called Io, Europa, Ganymede and Callisto. For the first three moons, the orbital period T of each is exactly twice the period of the one orbiting immediately inside it. That is,

$$T_{\text{Europa}} = 2 \times T_{\text{Io}}$$

$$T_{\text{Ganymede}} = 2 \times T_{\text{Europa}}$$

The mass of Jupiter is 1.90×10^{27} kg, and the orbital radius of Io is 421 600 km.

(b) Calculate Ganymede's orbital speed.

or!

find T_G from K's 3rd

then use

$$v = \frac{2\pi R}{T}$$

$$F_c = F_g$$

$$\frac{mv^2}{R} = G \frac{mM}{R^2}$$

$$v = \sqrt{\frac{GM}{R}}$$

$$= \sqrt{\frac{6.67 \times 10^{-11} \times 1.9 \times 10^{27}}{1.062 \times 10^9}}$$

$$=$$

2004 HSC QUESTION

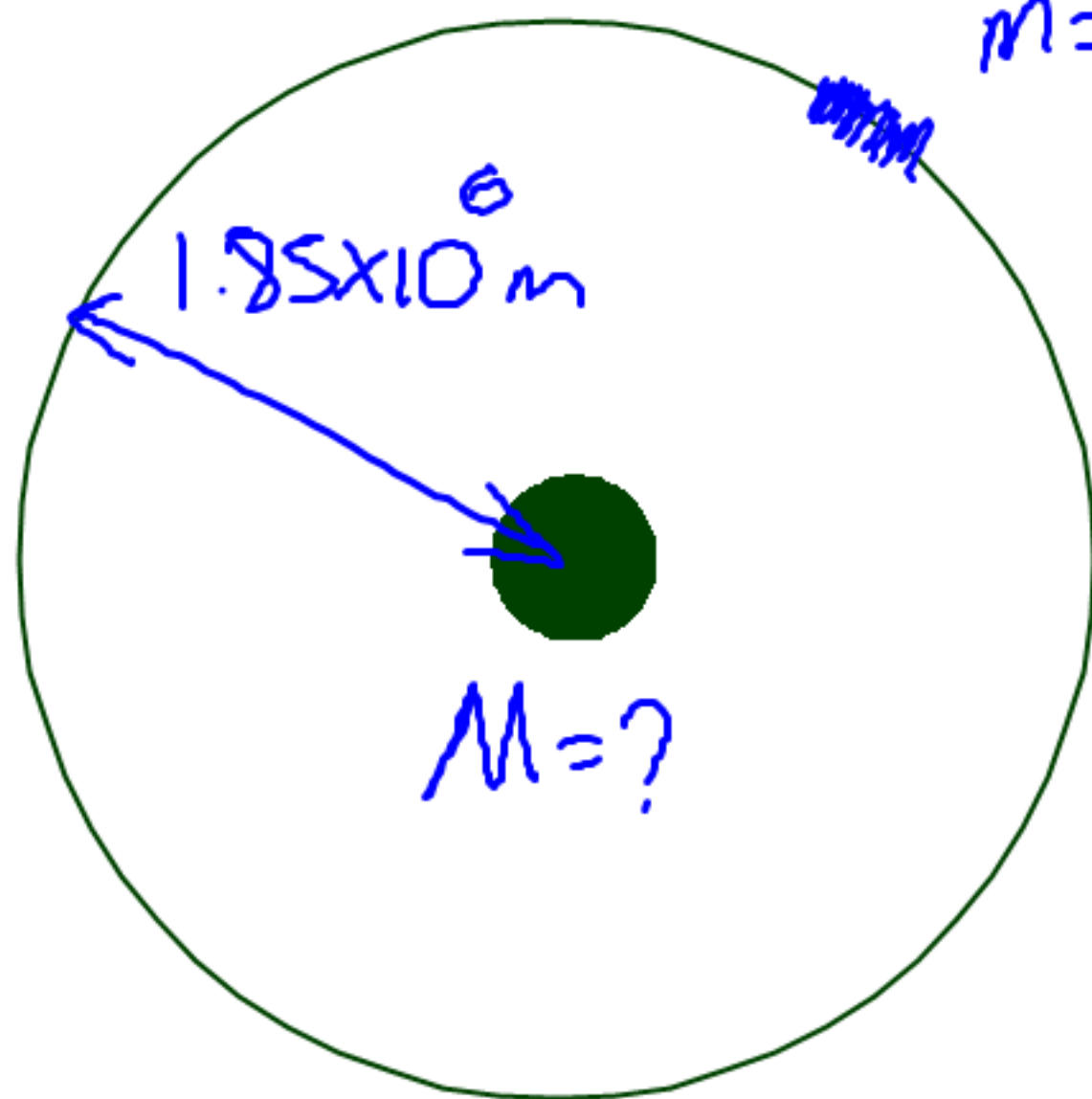
Question 17 (6 marks)

In July 1969 the Apollo 11 Command Module with Michael Collins on board orbited the Moon waiting for the Ascent Module to return from the Moon's surface. The mass of the Command Module was 9.98×10^3 kg, its period was 119 minutes, and the radius of its orbit from the Moon's centre was 1.85×10^6 metres.

(a) Assuming the Command Module was in circular orbit, calculate

(i) the mass of the Moon;

$$T = 119 \text{ min} = 119 \times 60 \text{ s.}$$



$$\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$$

$$GM T^2 = R^3 4\pi^2$$

$$M = \frac{R^3 4\pi^2}{G \cdot T^2}$$

$$= \frac{(1.85 \times 10^6)^3 4\pi^2}{6.67 \times 10^{-11} \times (119 \times 60)^2}$$

$$= 7.35 \times 10^{22} \text{ kg}$$

$$v = \frac{2\pi R}{T} = \sqrt{\frac{GM}{R}}$$

$$M = \frac{4\pi^2 R^3}{6 \cdot T^2}$$

$$\frac{4\pi^2 R^2}{T^2} = \frac{GM}{R}$$

2004 HSC QUESTION

Question 17 (6 marks)

In July 1969 the Apollo 11 Command Module with Michael Collins on board orbited the Moon waiting for the Ascent Module to return from the Moon's surface. The mass of the Command Module was 9.98×10^3 kg, its period was 119 minutes, and the radius of its orbit from the Moon's centre was 1.85×10^6 metres.

(ii) the magnitude of the orbital velocity of the Command Module.

2

$$V = \frac{2\pi R}{T} = \sqrt{\frac{GM}{R}} = 1600 \text{ m/s}$$

2004 HSC QUESTION

Question 17 (6 marks)

In July 1969 the Apollo 11 Command Module with Michael Collins on board orbited the Moon waiting for the Ascent Module to return from the Moon's surface. The mass of the Command Module was 9.98×10^3 kg, its period was 119 minutes, and the radius of its orbit from the Moon's centre was 1.85×10^6 metres.

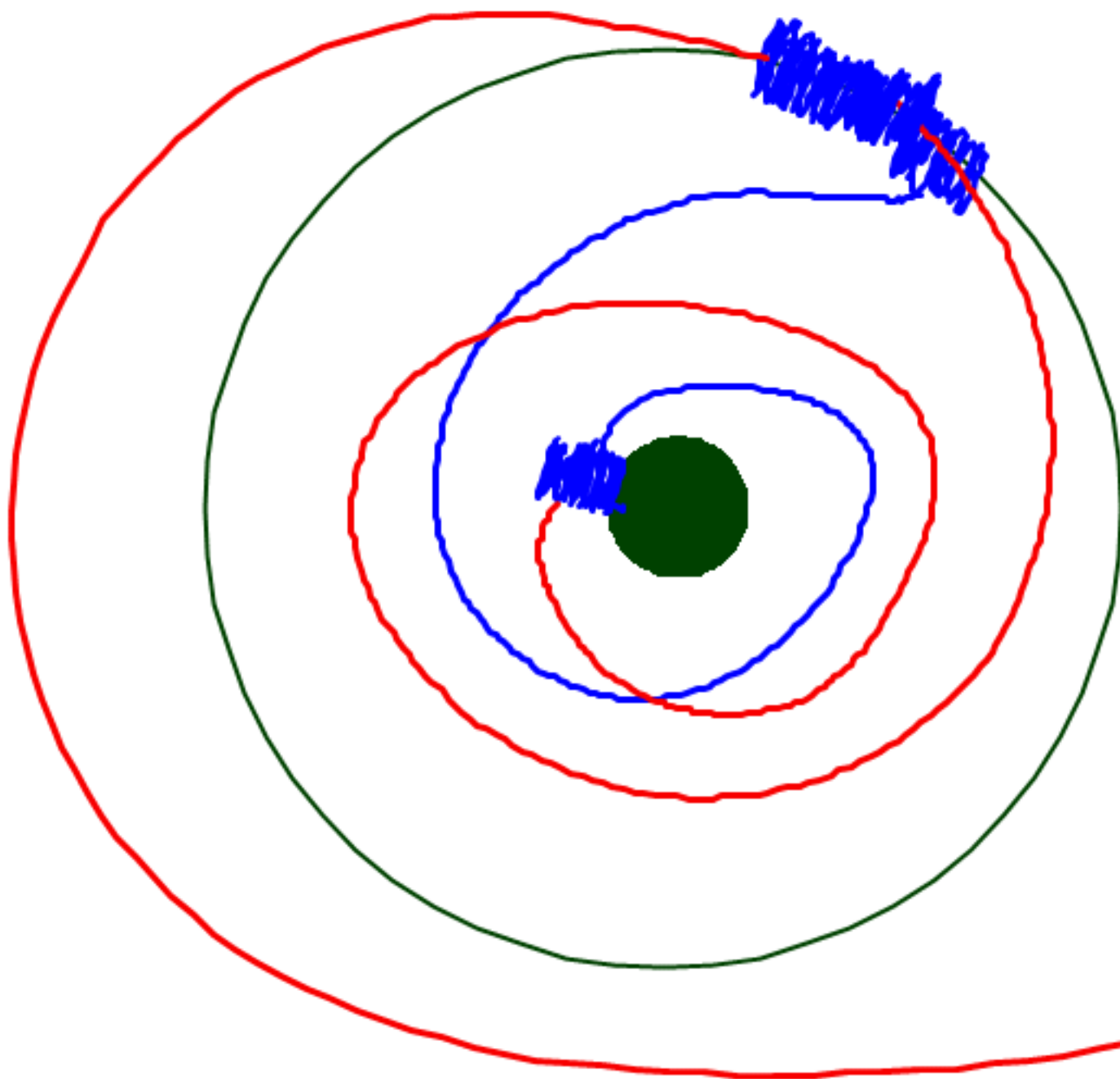
- (b) The docking of the Ascent Module with the Command Module resulted in an increase in mass of the orbiting spacecraft. The spacecraft remained at the same altitude.

This docking procedure made no difference to the orbital speed. Justify this statement.

$$v = \sqrt{\frac{GM}{R}}$$

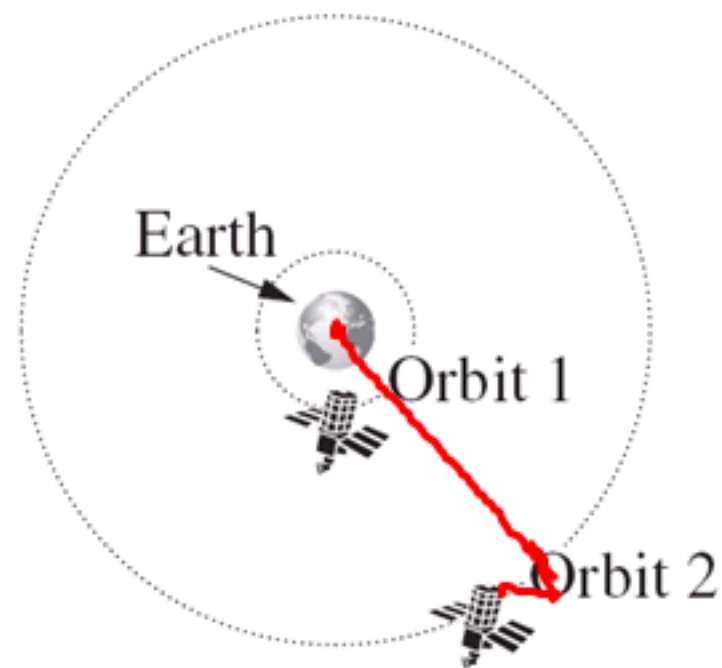
2

$$\frac{R^3}{T^2} = \frac{GM}{4\pi^2}$$



2008 HSC QUESTION

(b) A satellite is propelled from Orbit 1 to Orbit 2 as shown in the diagram.



$$\frac{mv^2}{r} = G \frac{mM}{r^2}$$

$$v = \sqrt{\frac{GM}{r}}$$

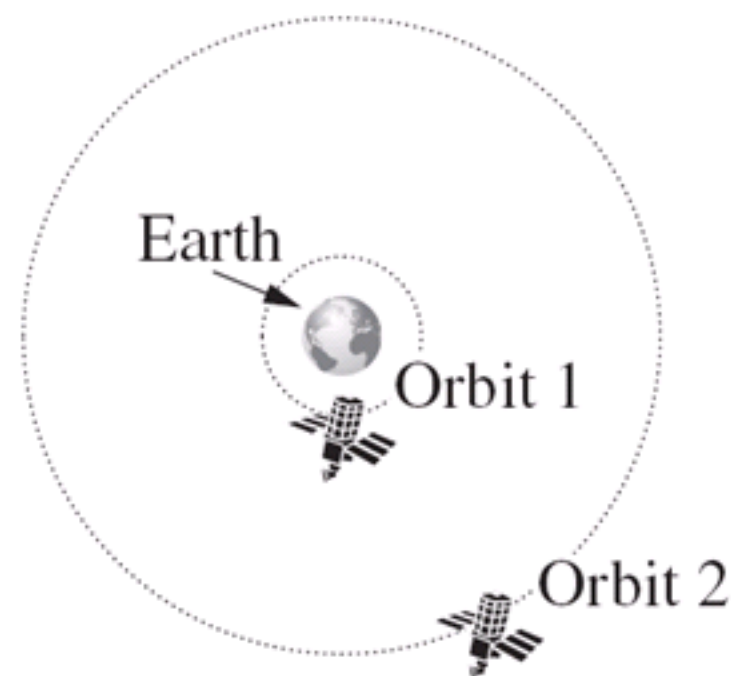
Orbit 2 has a radius of 27 000 km. What is the satellite's speed in this orbit?

3

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{27 \times 10^6}} = 3800 \text{ m/s}$$

2008 HSC QUESTION

(b) A satellite is propelled from Orbit 1 to Orbit 2 as shown in the diagram.



$$\frac{R_1^3}{T_1^2} = \frac{R_2^3}{T_2^2}$$

(c) The radius of Orbit 2 is four times that of Orbit 1. What is the ratio of the new orbital period to the original period?

2

$$\rightarrow R_2 = 4R_1$$

what is $\frac{T_2}{T_1} = 8$

$$\frac{R_1^3}{T_1^2} = \frac{(4R_1)^3}{T_2^2}$$

$$\frac{\cancel{R_1^3}}{T_1^2} = \frac{64\cancel{R_1^3}}{T_2^2} \Rightarrow$$

$$\sqrt{64T_1^2} = \sqrt{T_2^2}$$

$$T_2 = 8T_1$$

2003 HSC PAPER

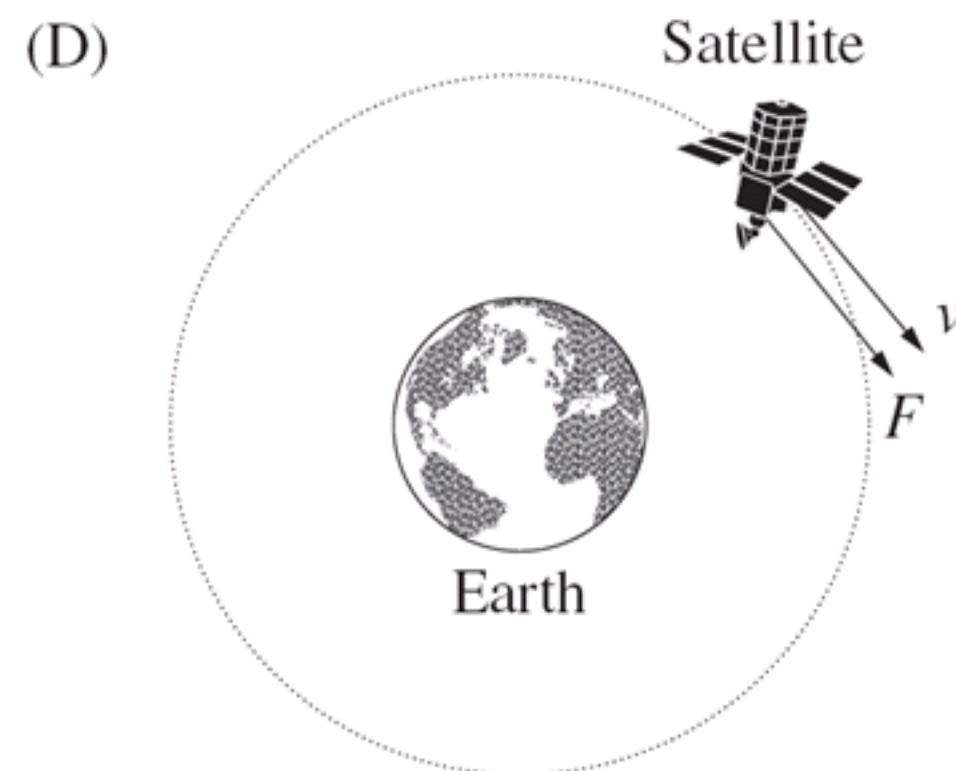
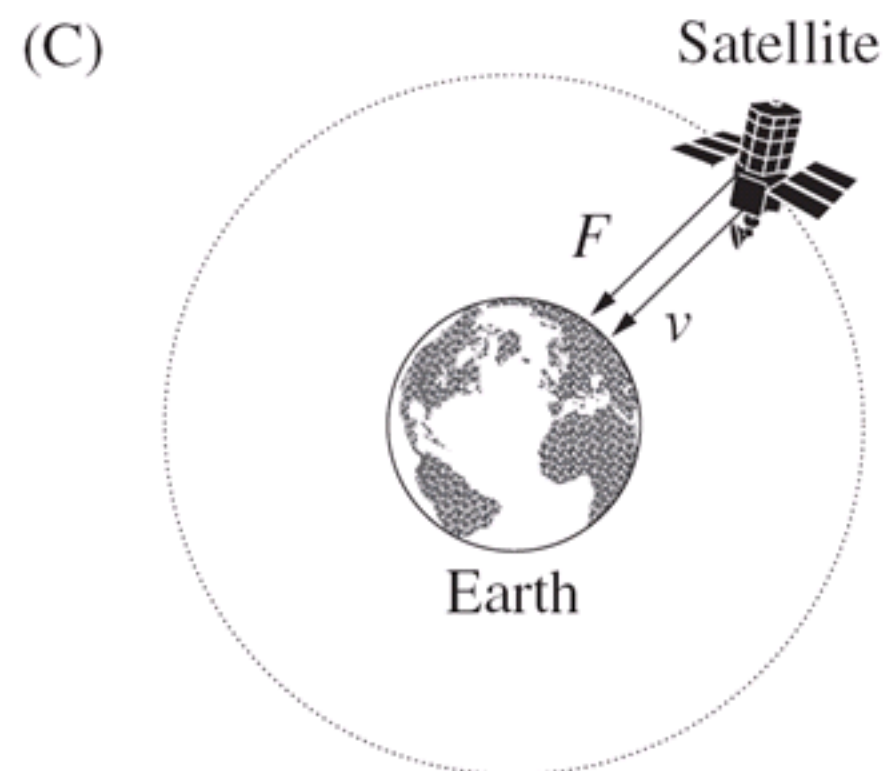
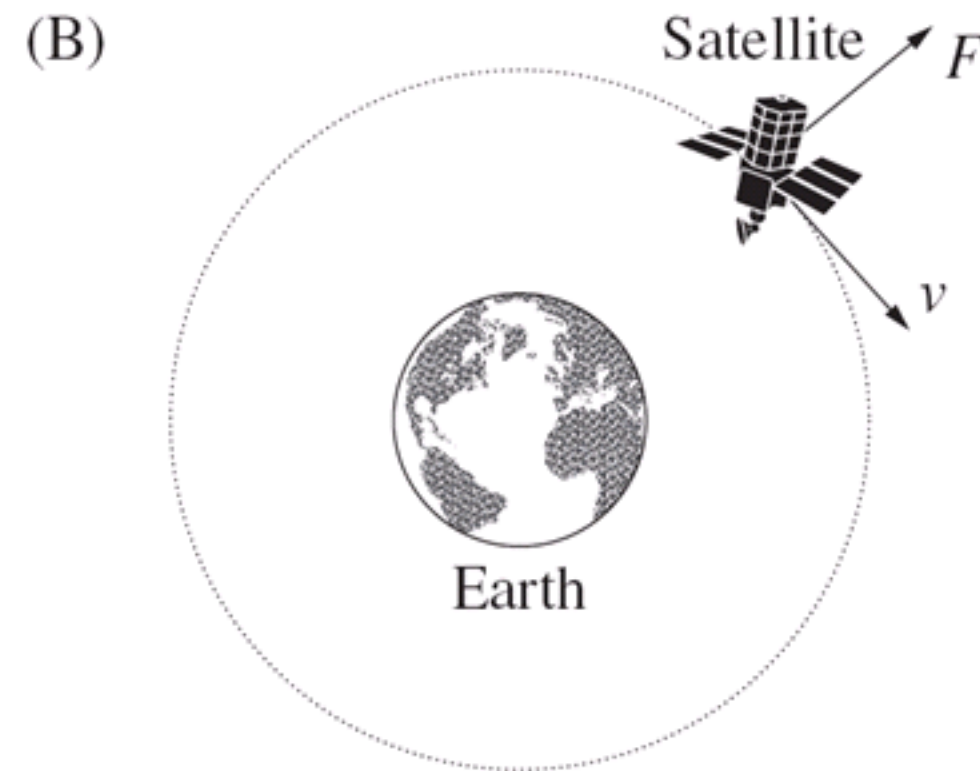
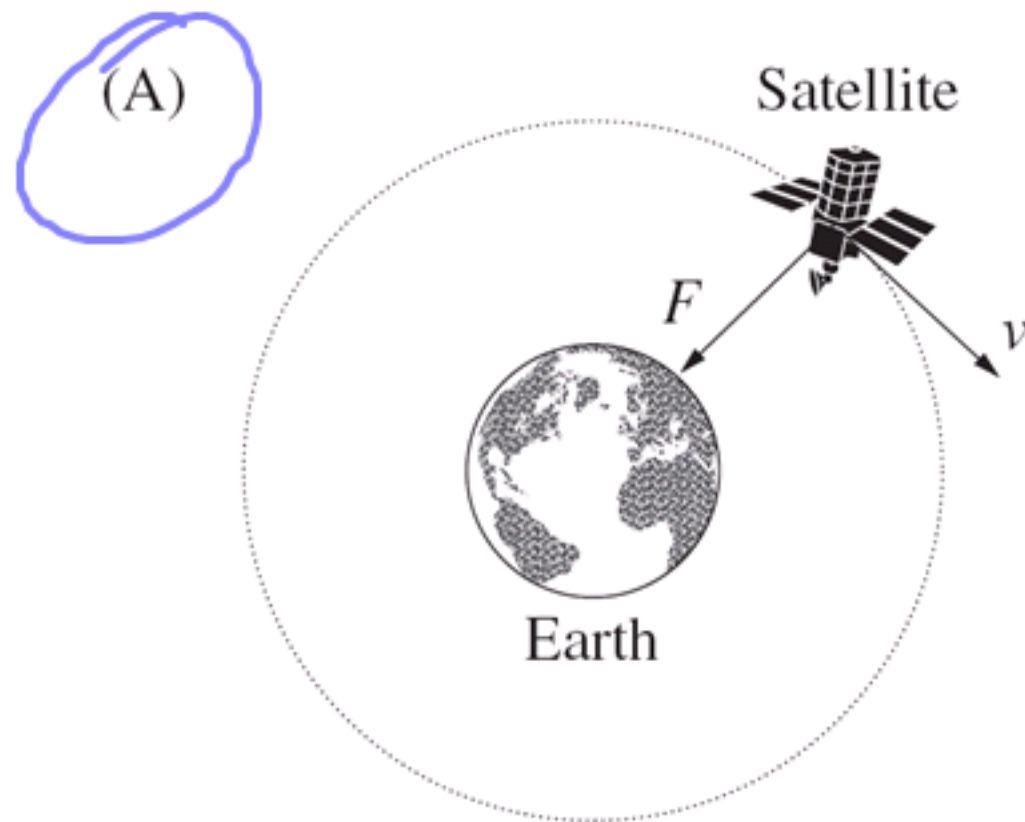
- 2 A satellite moves in uniform circular motion around Earth.

The following table shows the symbols used in the diagrams below.
These diagrams are NOT drawn to scale.

Key

F	net force on satellite
v	velocity of satellite

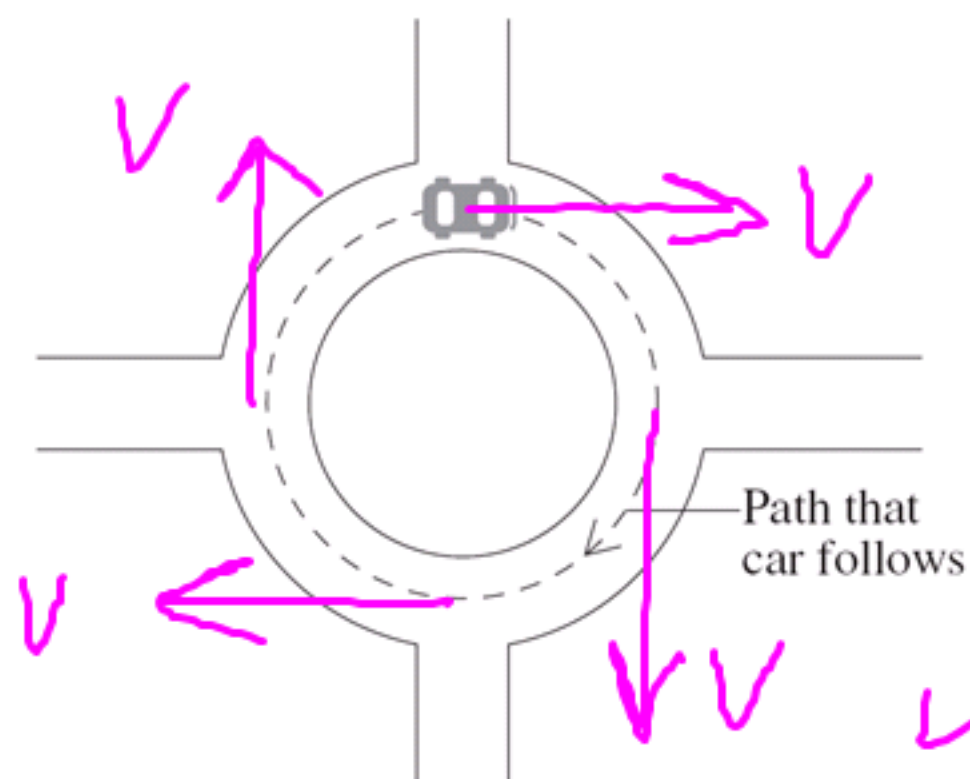
Which diagram shows the direction of F and v at the position indicated?



2004 HSC PAPER

Question 18 (4 marks)

A car with a mass of 800 kg travels at a constant speed of 7.5 m s^{-1} on a roundabout so that it follows a circular path with a radius of 16 m.

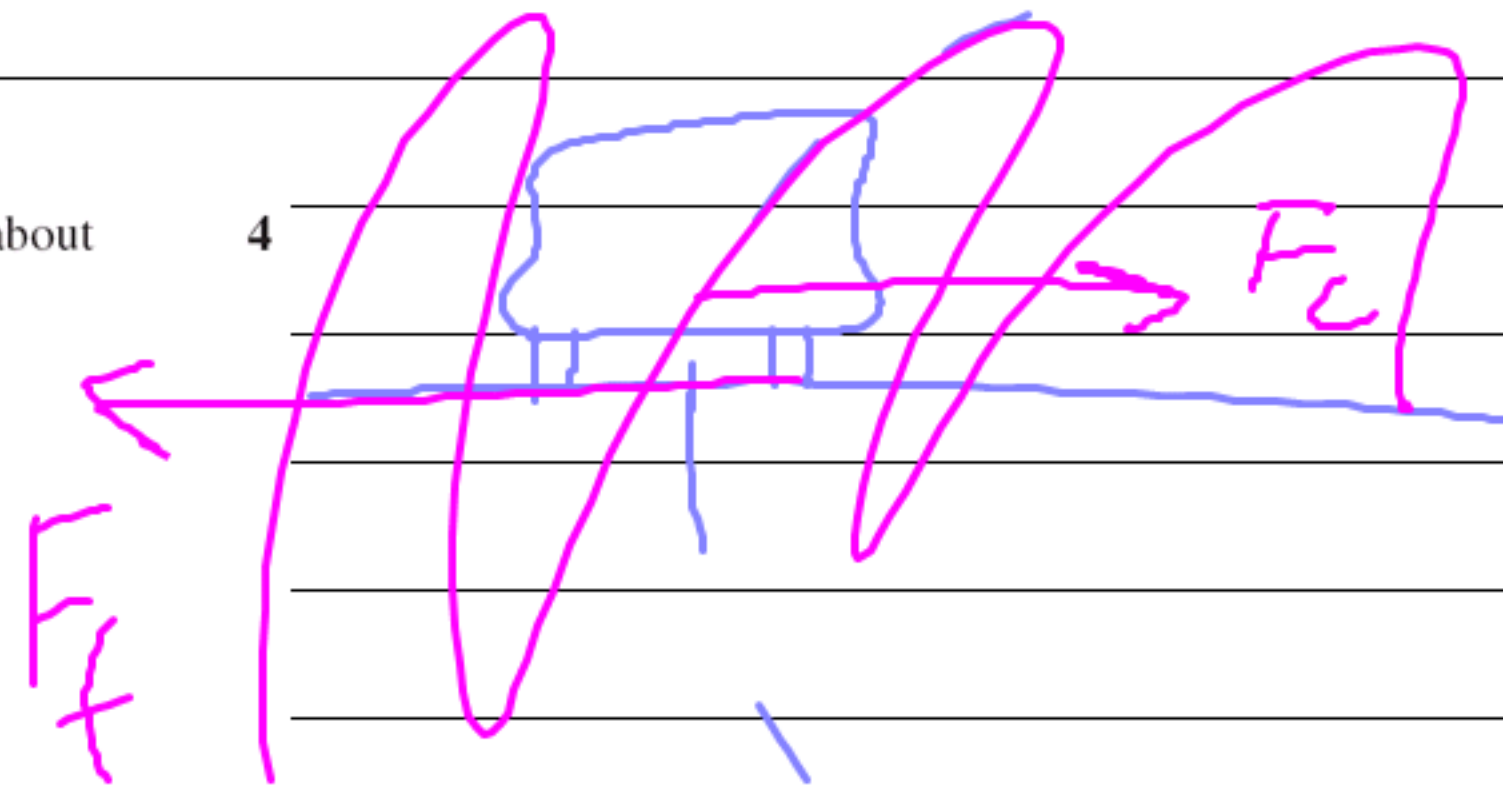


A person observing this situation makes the following statement.

'There is no net force acting on the car because the speed is constant and the friction between the tyres and the road balances the centripetal force acting on the car.'

Assess this statement. Support your answer with an analysis of the horizontal forces acting on the car, using the numerical data provided above.

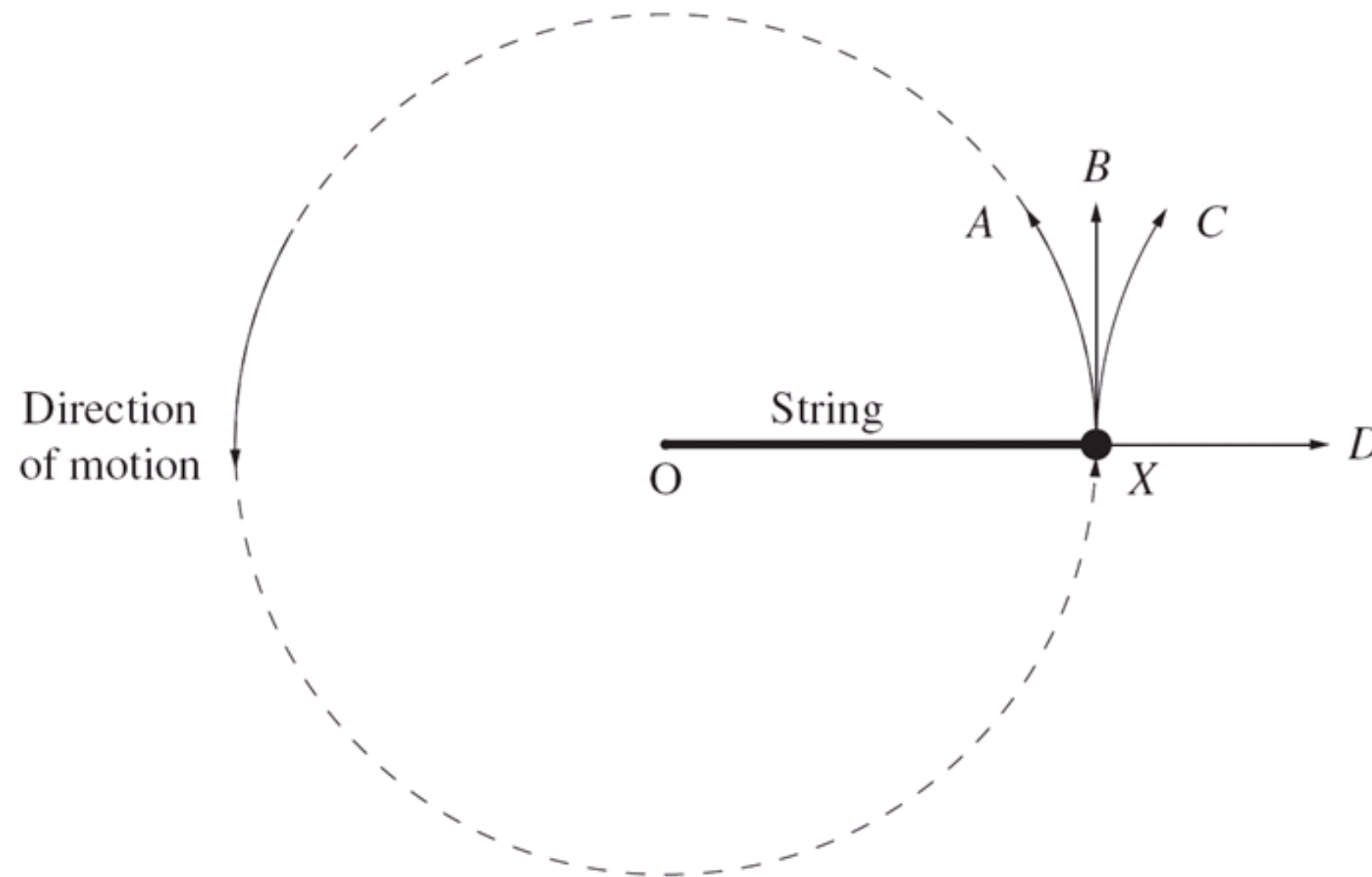
4



$$F_f = F_c = F_{net}$$

$\Rightarrow a \checkmark$
 $\Delta v \checkmark$

- 2 A mass attached to a length of string is moving in a circular path around a central point, O, on a flat, horizontal, frictionless table. This is depicted in the diagram below. The string breaks as the mass passes point X.



Which line best depicts the subsequent path of the mass?

- (A) Line A
- (B) Line B
- (C) Line C
- (D) Line D

2005 HSC QUESTION

- 5 Napoleon attacked Moscow in 1812 with his cannon firing a shot at an elevation angle of 40° . Napoleon then decided to fire a second shot at the same speed but at an elevation angle of 50° .

Which of the following observations would Napoleon expect to be true about the second shot when compared with the first?

- (A) Longer range
- (B) Shorter range
- (C) Longer time of flight
- (D) Shorter time of flight

2004 HSC QUESTION

Question 27 (4 marks)

A sports magazine commenting on the athletic ability of Michael Jordan, the famous basketball player said: **4**

‘Being an athlete takes more brains than brawn. It takes time and effort. It takes endurance and commitment. It takes an athlete who can stay in the air for 2.5 seconds while shooting a goal; an athlete who knows which laws of physics keep him there.’

Assess the information presented in this magazine, using appropriate calculations to support your argument.

2004 HSC QUESTION

Question 16 (4 marks)

A projectile is fired at a velocity of 50 m s^{-1} at an angle of 30° to the horizontal.

4

Determine the range of the projectile.

HOMEWORK

- ✦ Homework is an integral part of your "Learning Curve", take it seriously!
- ✦ Target minimum 1 hour of Physics everyday
- ✦ Divide your physics home study in three segments;
 - ✓ Revision (past)
 - ✓ Homework (present)
 - ✓ Tomorrow (future)
- ✦ Homework is due next period, unless otherwise stated
- ✦ If you cannot do all, at least do a few from each piece

*Apart from **reading the relevant pages from the textbook and solving the rest of the questions in this booklet** your homework is:*

1. Space 2 Past Year Questions
2. ChAapter 3 all questions
3. Experiment 3 of the Practical Booklet

Also

Circular Motion Worksheet

New Booklet (8 page)

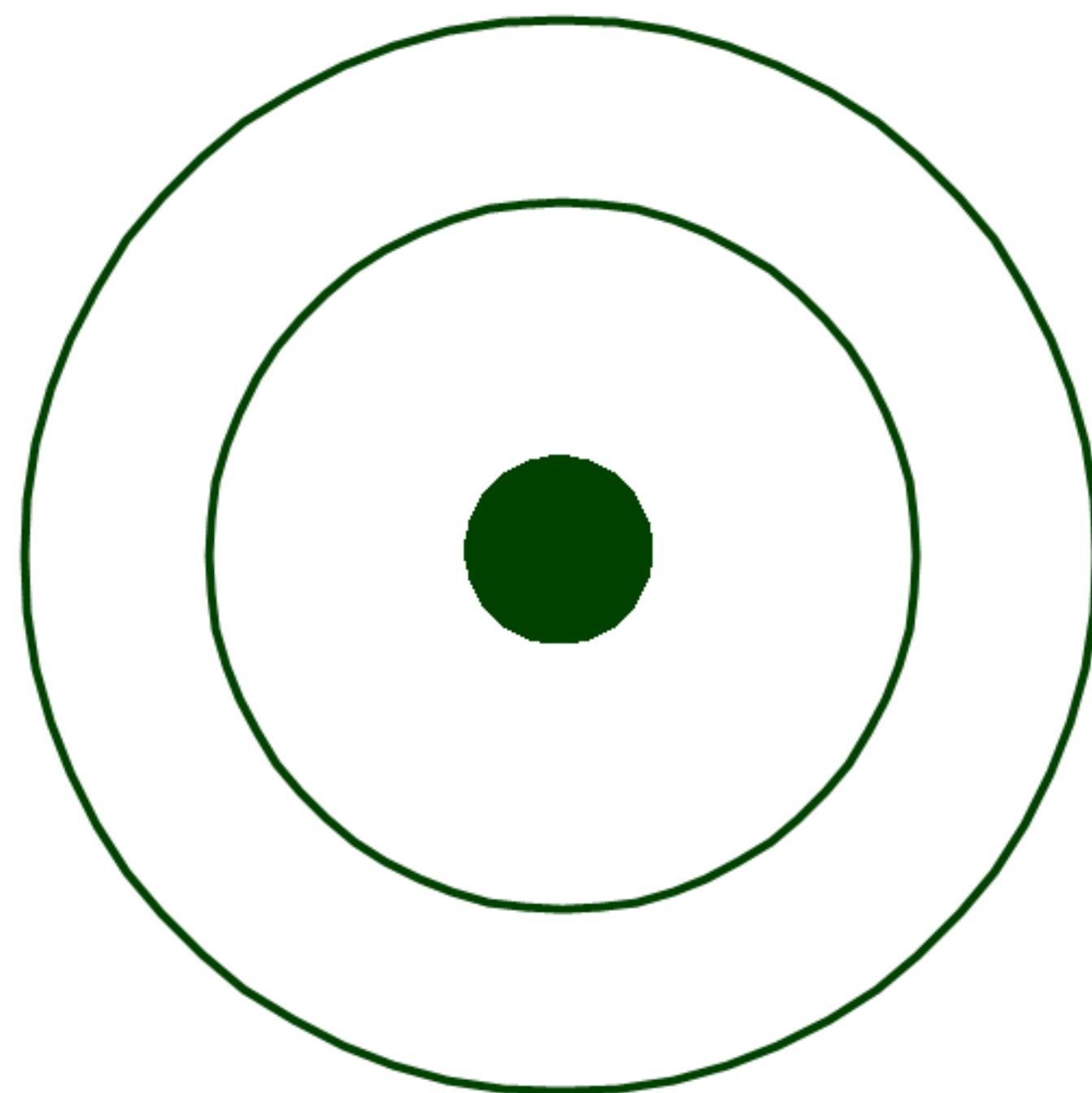
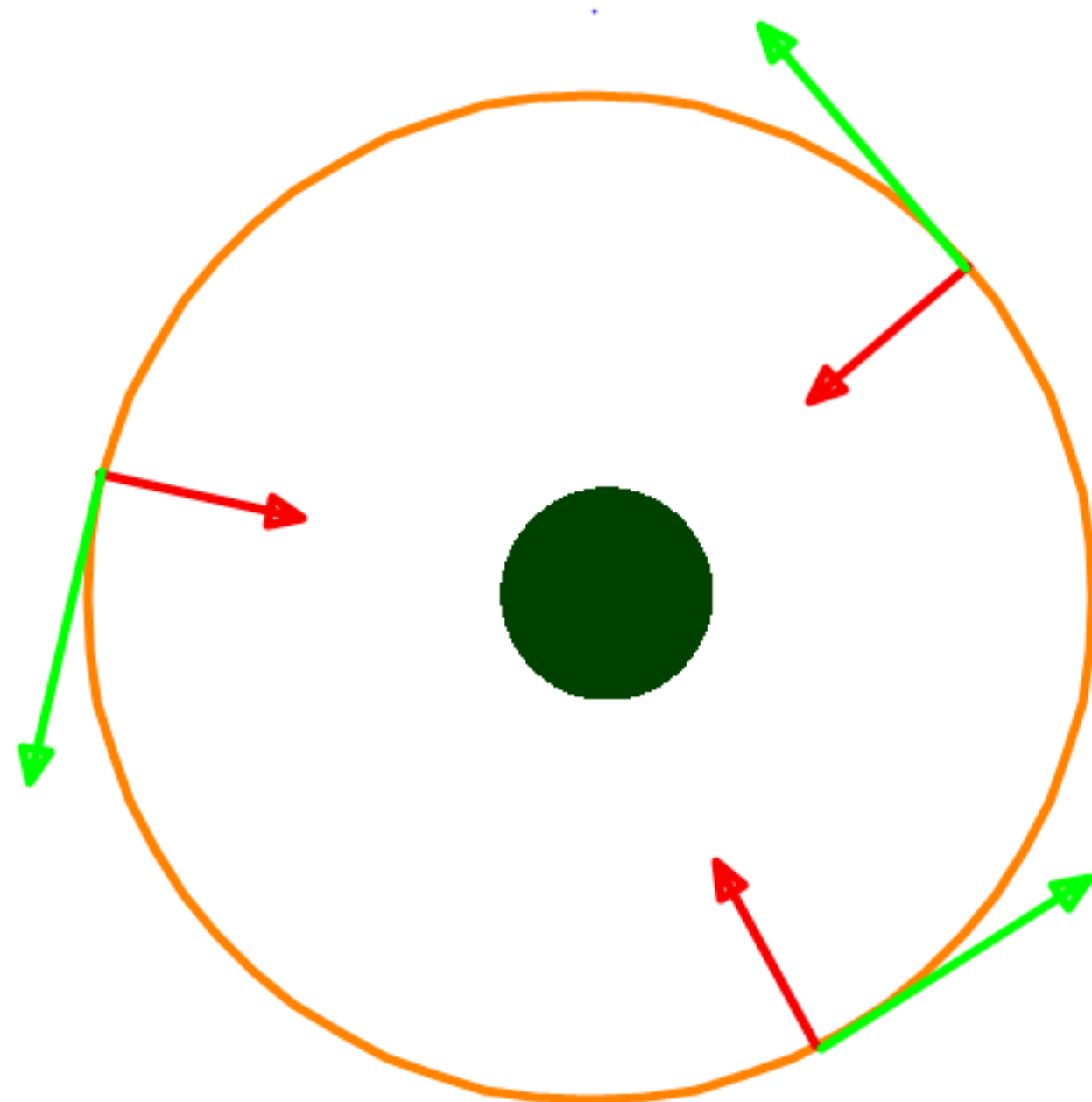
Chapter 2 All Questions

PM Practice Booklet

All Questions in Period 7 & 8 Booklets

Experiment 4 Report

NEXT PERIOD > SAFE RE-ENTRY



Steps in solving PM questions.

Step 1 > Read the question.

Step 2 > Understand the question.

Step 3 > Make sure you understand "What is given/provided" and "What is asked".

Step 4 > Draw a diagram.

Step 5 > Select your interval (A to B). Mark A and B on your diagram.

Step 6 > Draw the data table and fill in the details as much as you can. Mark unknowns.

Step 7 > Select the appropriate formula and solve it for unknowns.

