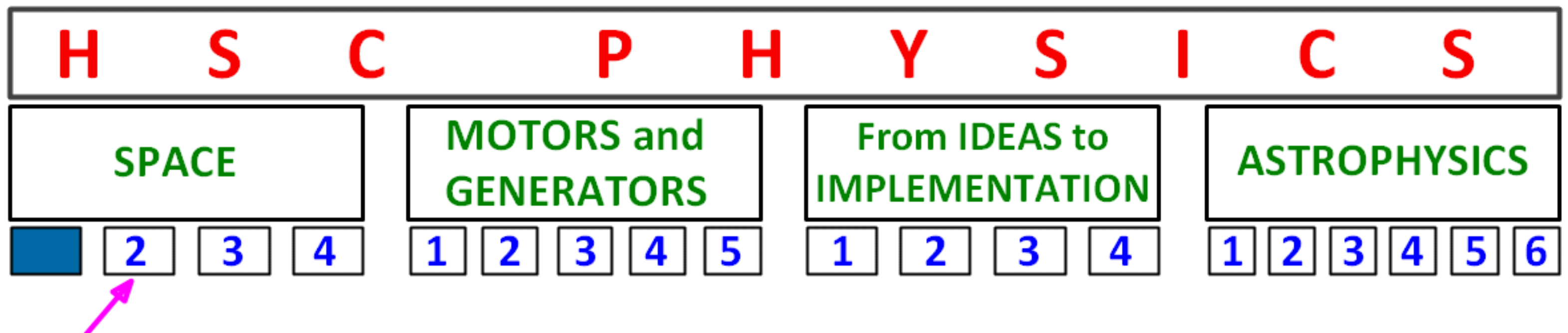


SPACE

1st Quarter; Module 1

PERIOD 16

Re-entry into Earth's Atmosphere



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:

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

COMPARISON OF LOW EARTH AND GEOSTATIONARY ORBITS

$g = \frac{GM}{r^2}$	LEO	GO
velocity	$\sim 7000 \text{ m/s}$	$= 3070 \text{ m/s}$
period	1.5 - 2 h	$= 24.00 \text{ h}$
altitude	250 - 1000 km	36000 km
orbital radius	6700 - 7400 km	42'000 km
atmospheric drag	Significant	None
purpose	human, telescopes GPS	communication

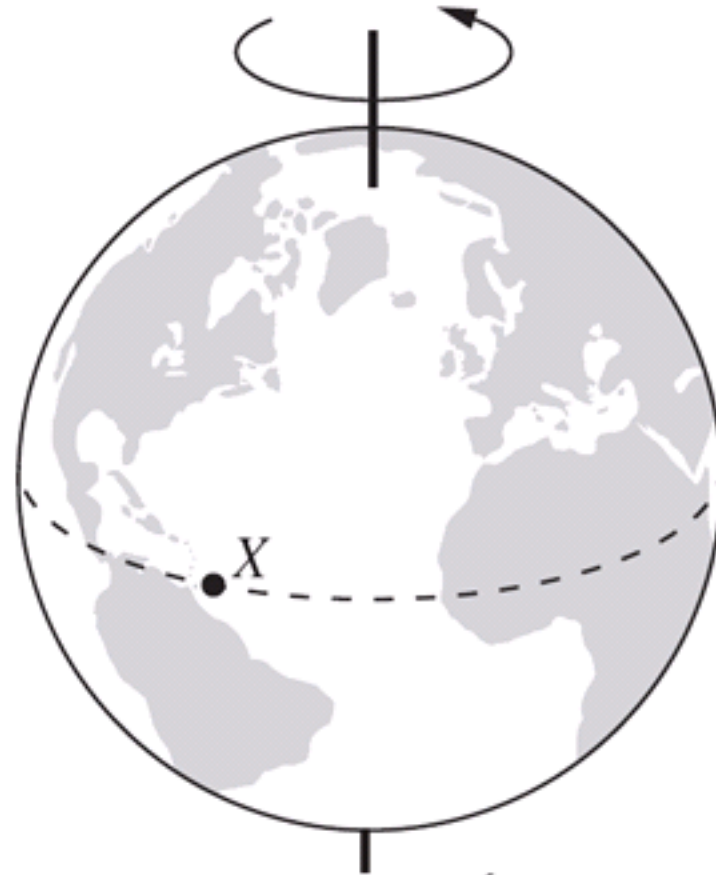
COMPARISON OF LOW EARTH AND GEOSTATIONARY ORBITS

	LEO	GO
What makes it special?	Under Van-Allen mag-field belts "PROTECTION FROM RADIATION & COSMIC PARTICLES FROM SPACE"	Above the same point on earth all the time

2007 HSC QUESTION

Question 17 (4 marks)

The diagram shows the position X on Earth's surface from which a satellite is to be launched into a geostationary orbit.



- (b) Given that the radius of Earth is 6.38×10^6 m, calculate the height of the satellite above Earth's surface.

3

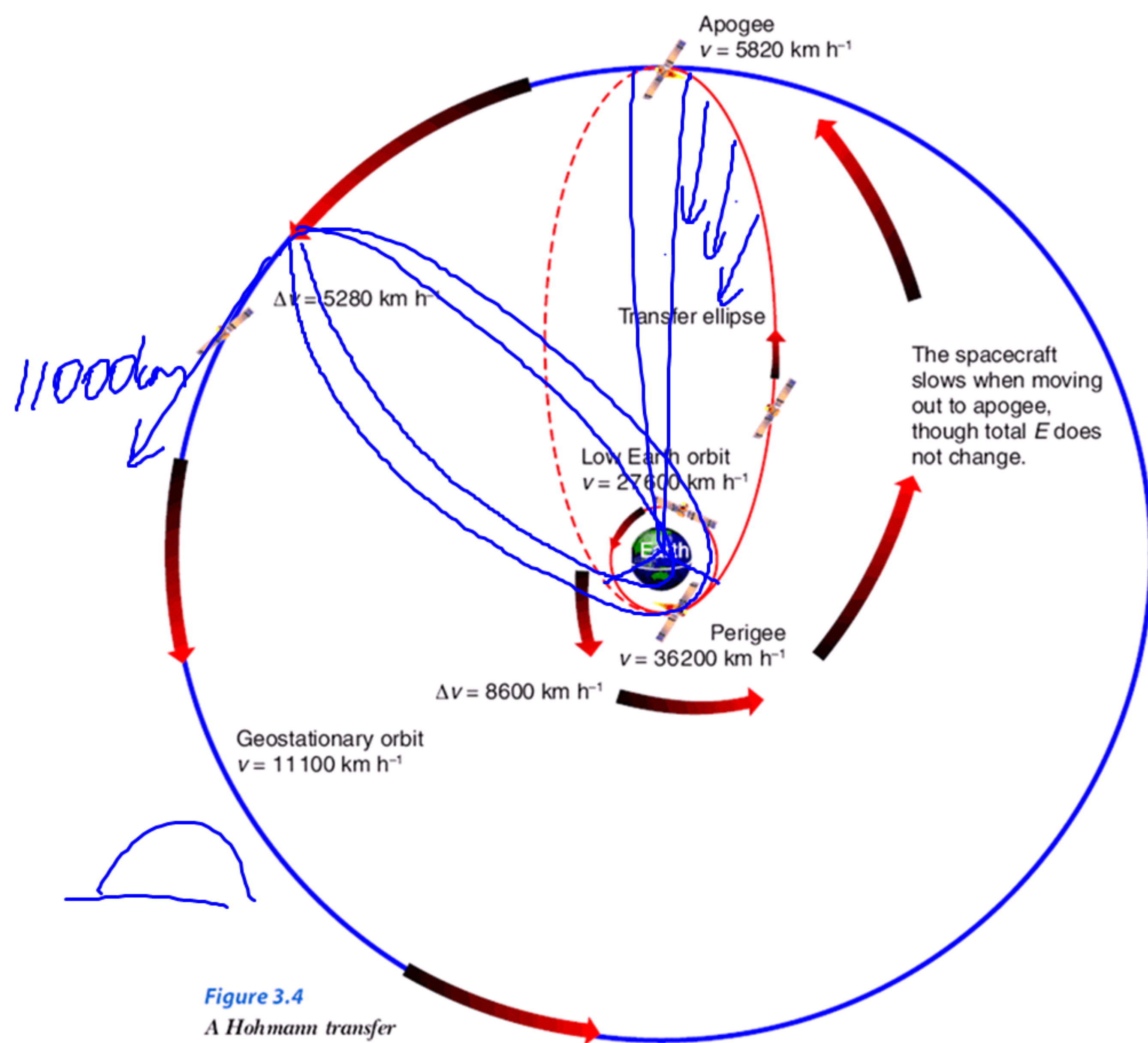


Figure 3.4

A Hohmann transfer orbit used to raise a satellite from a low Earth orbit of altitude 400 km up to a geostationary orbit of altitude 35 800 km

ISSUES ASSOCIATED WITH SAFE RE-ENTRY AND LANDING

1. DE-ORBITING

1. RETROBURNING THE ROCKETS
2. GLIDING
3. RE-ENTRY

2. RE-ENTRY ANGLE

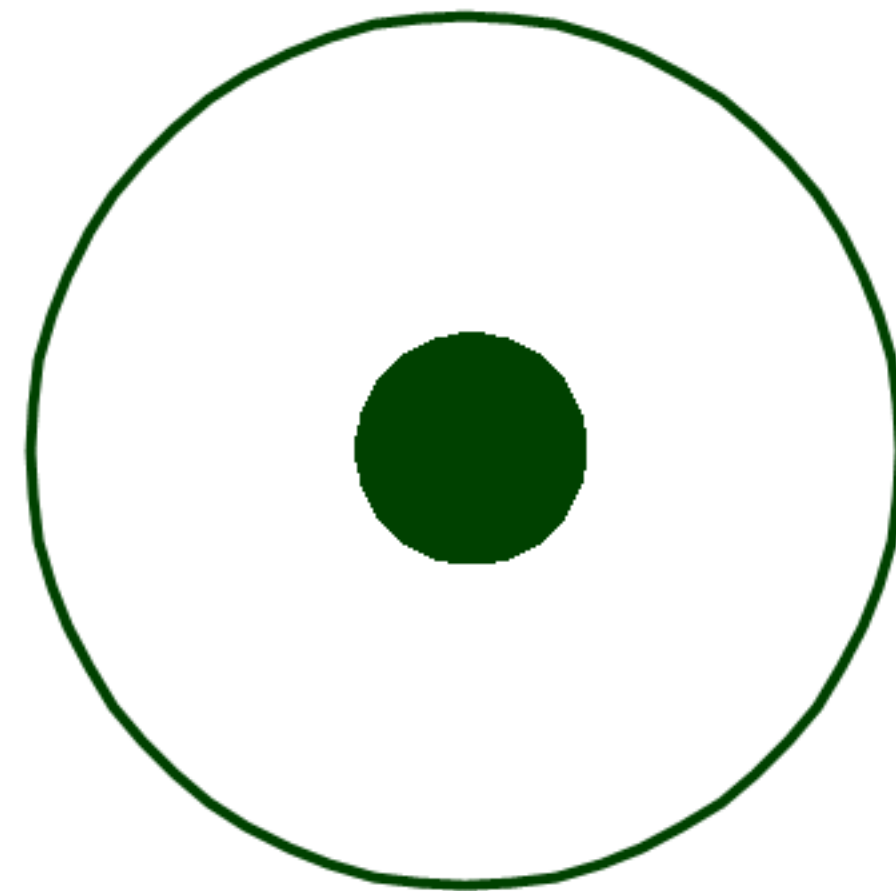
WHAT IF TOO DEEP?
WHAT IF TOO SHALLOW?

PROBLEMS

1. EXTREME HEAT
2. DECELERATING "g" FORCES
3. IONISATION BLACKOUT

3. LANDING

OLD US METHOD
OLD RUSSIAN METHOD
UPDATED RUSSIAN-CHINEESE METHOD
SPACE SHUTTLE



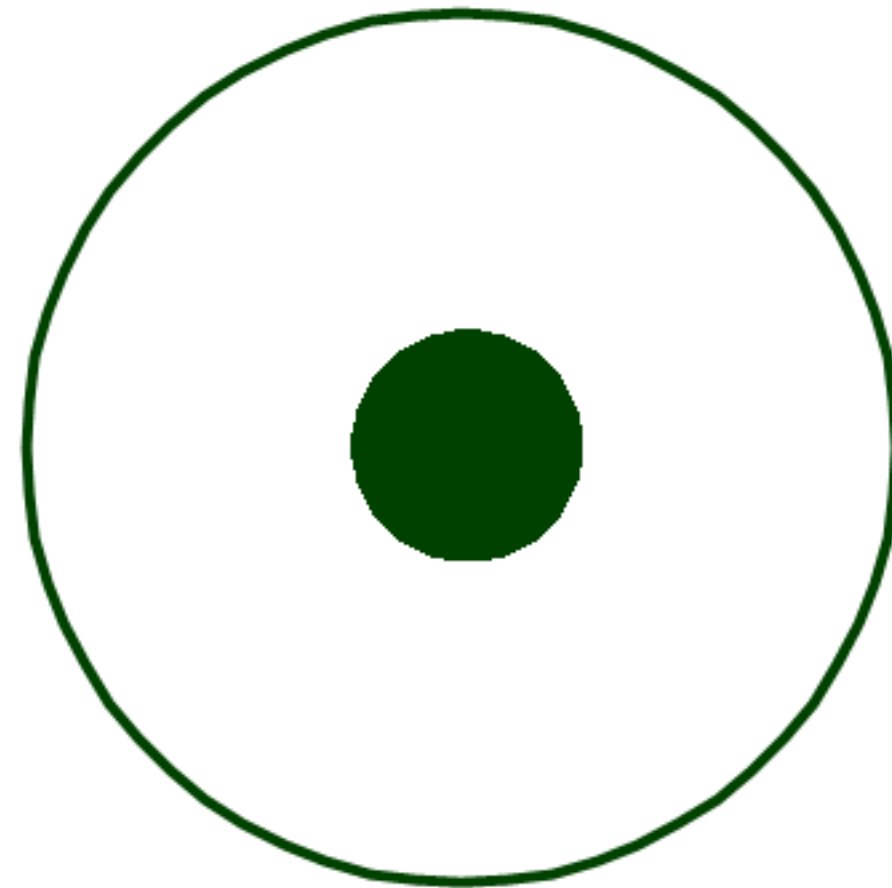
ISSUES ASSOCIATED WITH **SAFE RE-ENTRY AND LANDING**

1. DE-ORBITING

"The process of deliberately leaving a stable Earth orbit and re-entering the atmosphere in order to return to the surface of the Earth"

Three main phases

1. RETROBURNING THE ROCKETS
2. GLIDING
3. RE-ENTRY



ISSUES ASSOCIATED WITH SAFE RE-ENTRY AND LANDING

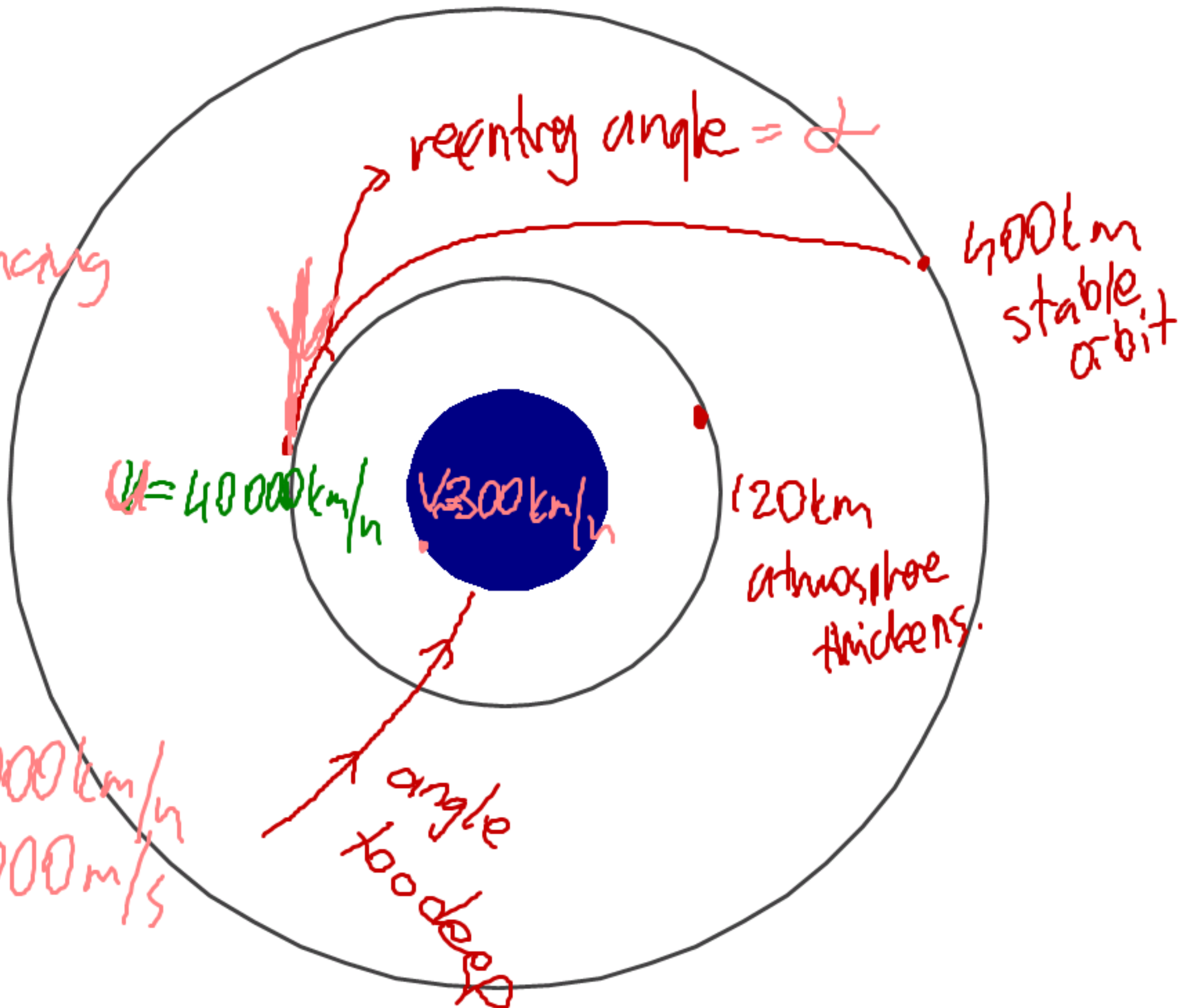
2. RE-ENTRY ANGLE

WHAT IF TOO DEEP?

→ very short descent time
too much decelerating g-forces, too much heat

WHAT IF TOO SHALLOW?

Bounce off
just like a
flat stone bouncing
off the lake.



$5.2^\circ < \alpha < 7.2^\circ$
Apollo missions

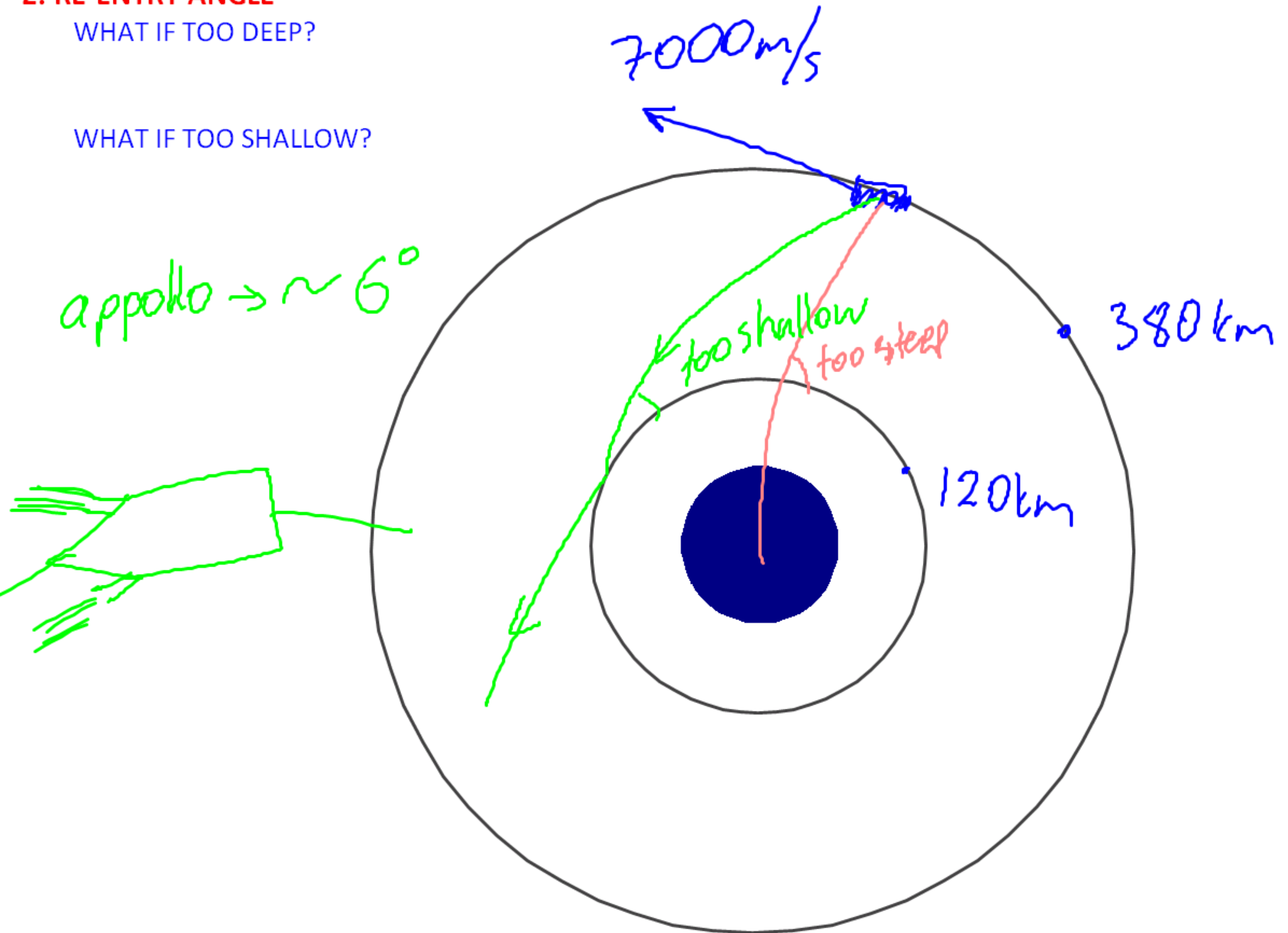
$$\Delta V = V - U$$
$$= \sim 40000 \text{ km/h}$$
$$\sim 10000 \text{ m/s}$$

ISSUES ASSOCIATED WITH SAFE RE-ENTRY AND LANDING

2. RE-ENTRY ANGLE

WHAT IF TOO DEEP?

WHAT IF TOO SHALLOW?



ISSUES ASSOCIATED WITH SAFE RE-ENTRY AND LANDING

2. RE-ENTRY ANGLE

PROBLEMS

1. EXTREME HEAT

at high altitude

GPE, KE

2. ~~DECELERATING "g" FORCES~~

at 120km

GPE, KE

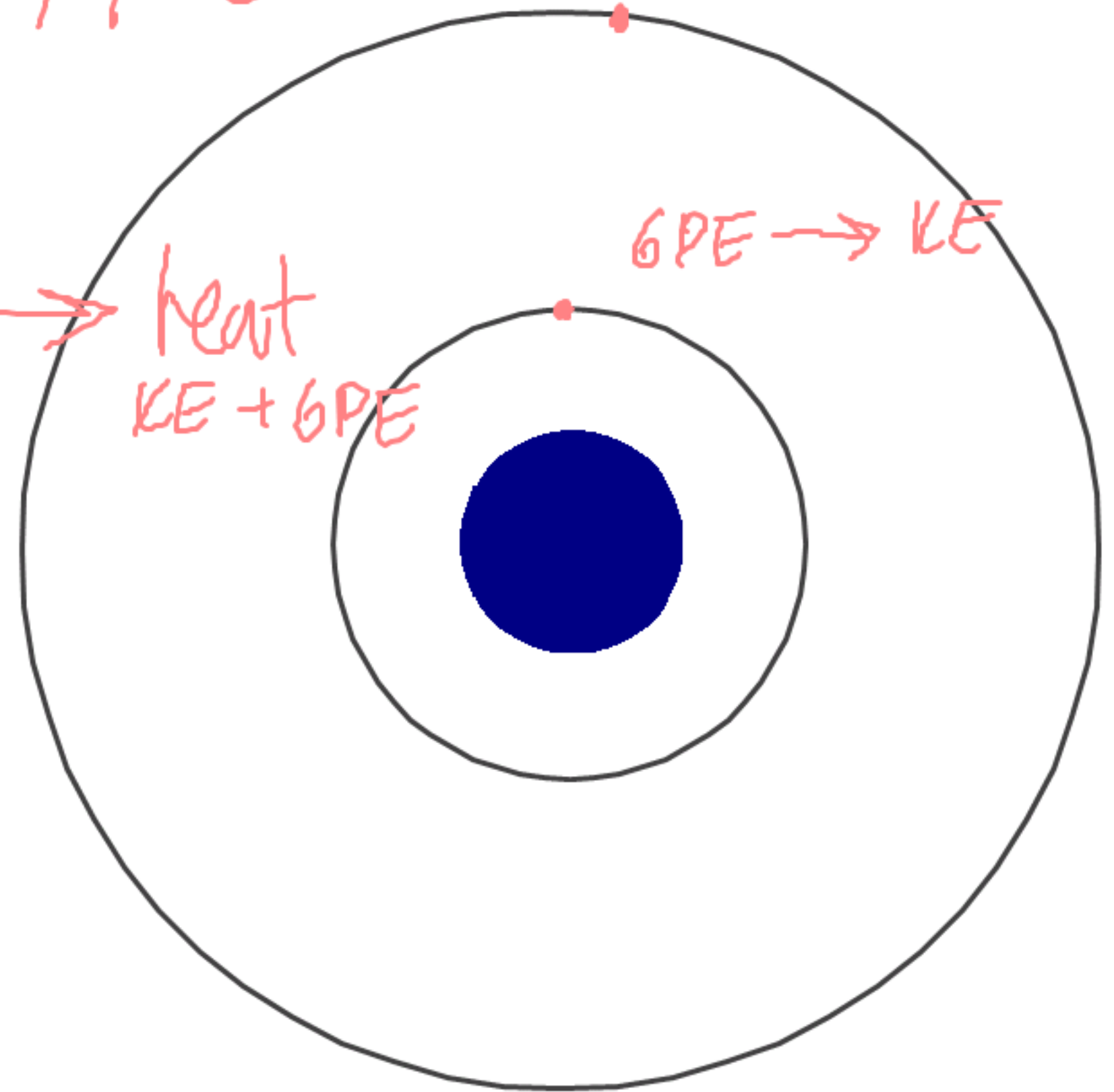
3. ~~IONISATION BLACKOUT~~

as it keeps descending

GPE or KE \rightarrow heat
KE + GPE

GPE, KE

GPE \rightarrow KE



$GPE \rightarrow KE \rightarrow \text{Heat}$

apollo \rightarrow 4-5 minutes

shuttle \rightarrow 15 minutes

$GPE \rightarrow KE$



$F_{\text{air resistance}}$

$v = 40000 \text{ km/h}$



$v = 4000 \text{ km/h}$

earth

ISSUES ASSOCIATED WITH SAFE RE-ENTRY AND LANDING

3. LANDING

OLD US METHOD - landing in sea, astranouts inside

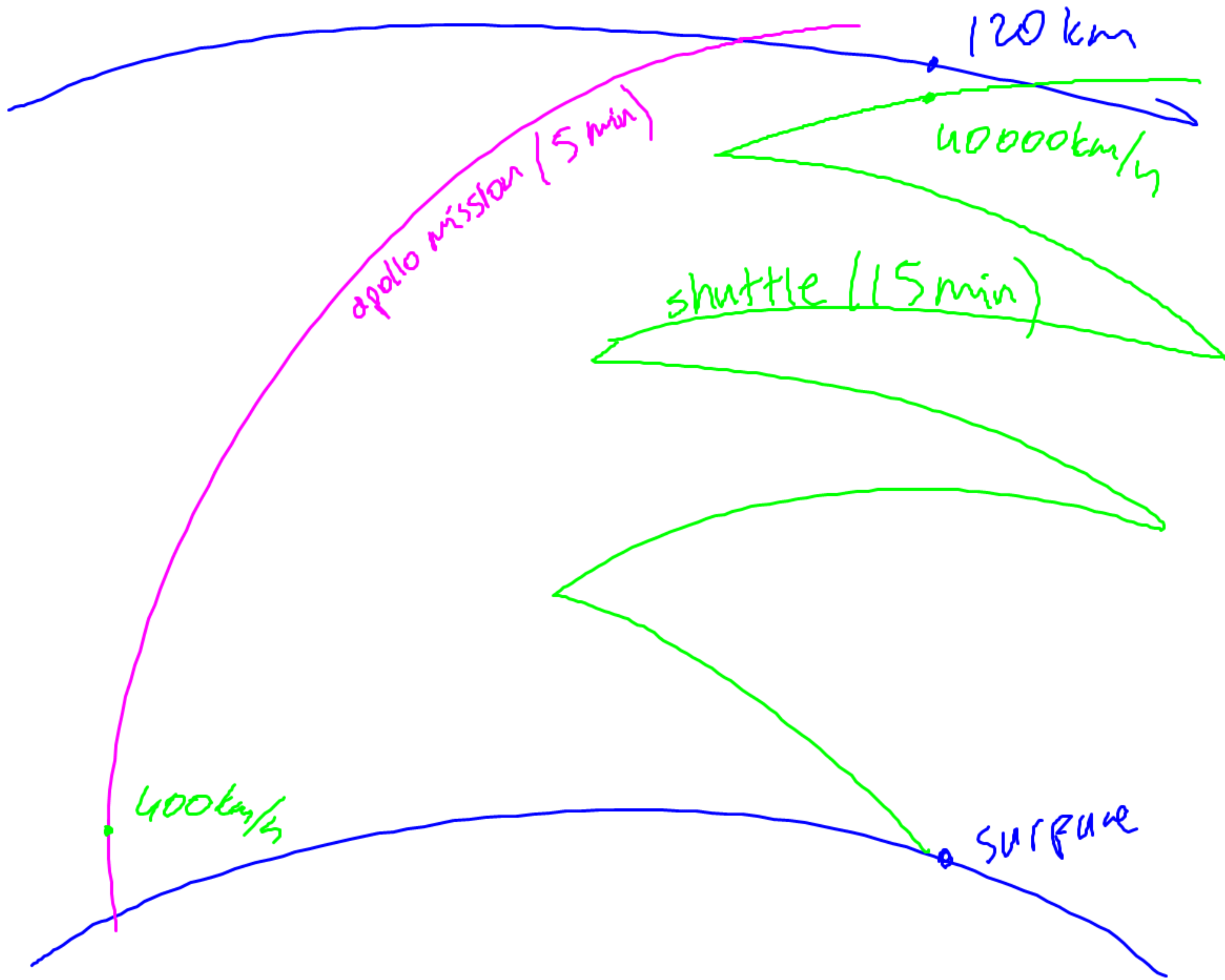
OLD RUSSIAN METHOD - landing on land, kozmonouts parachuted

ISSUES ASSOCIATED WITH SAFE RE-ENTRY AND LANDING

3. LANDING

UPDATED US, RUSSIAN & CHINEESE METHOD - landing on land, astranouts inside

SPACE SHUTTLE - like an airliner



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

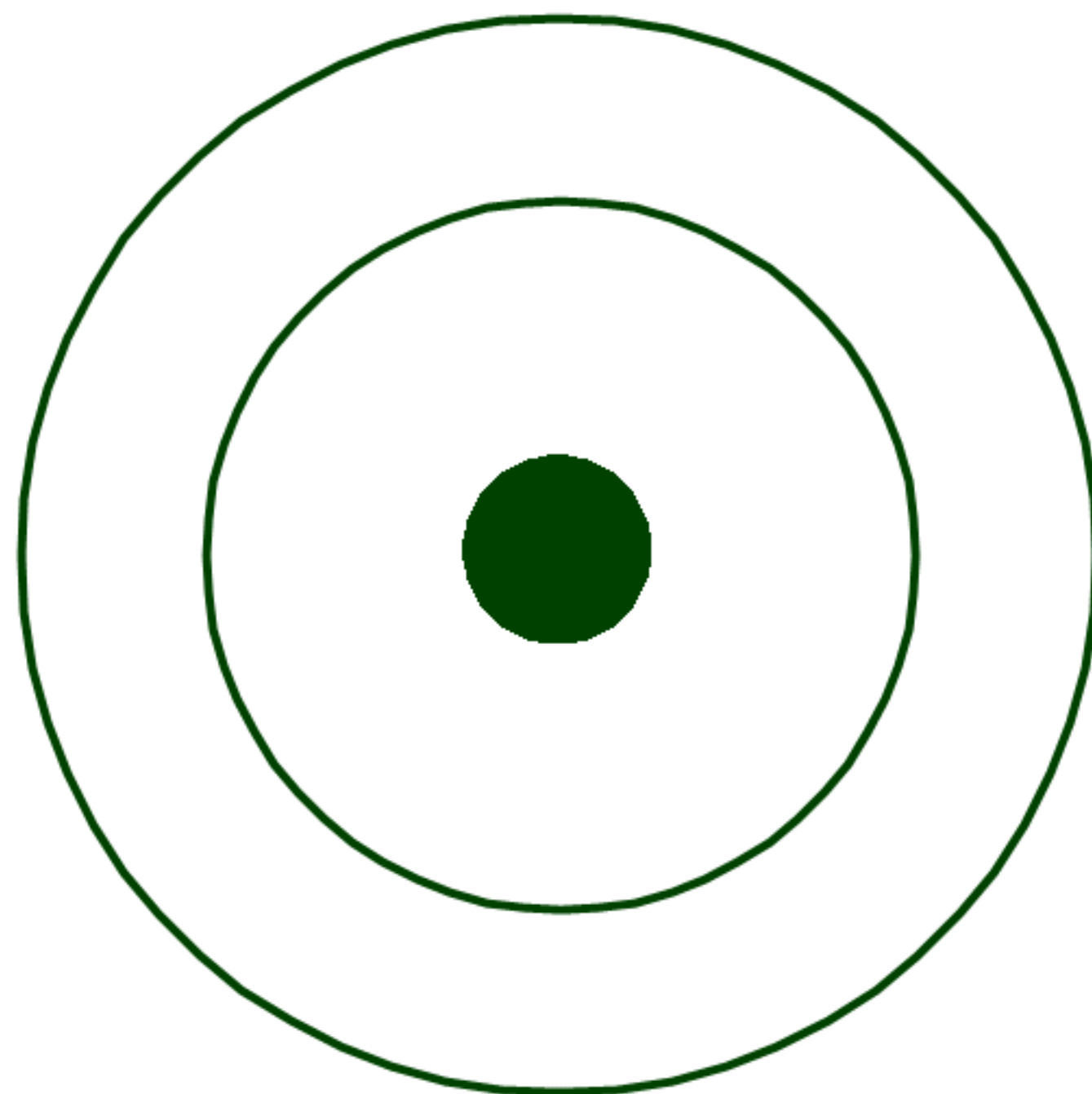
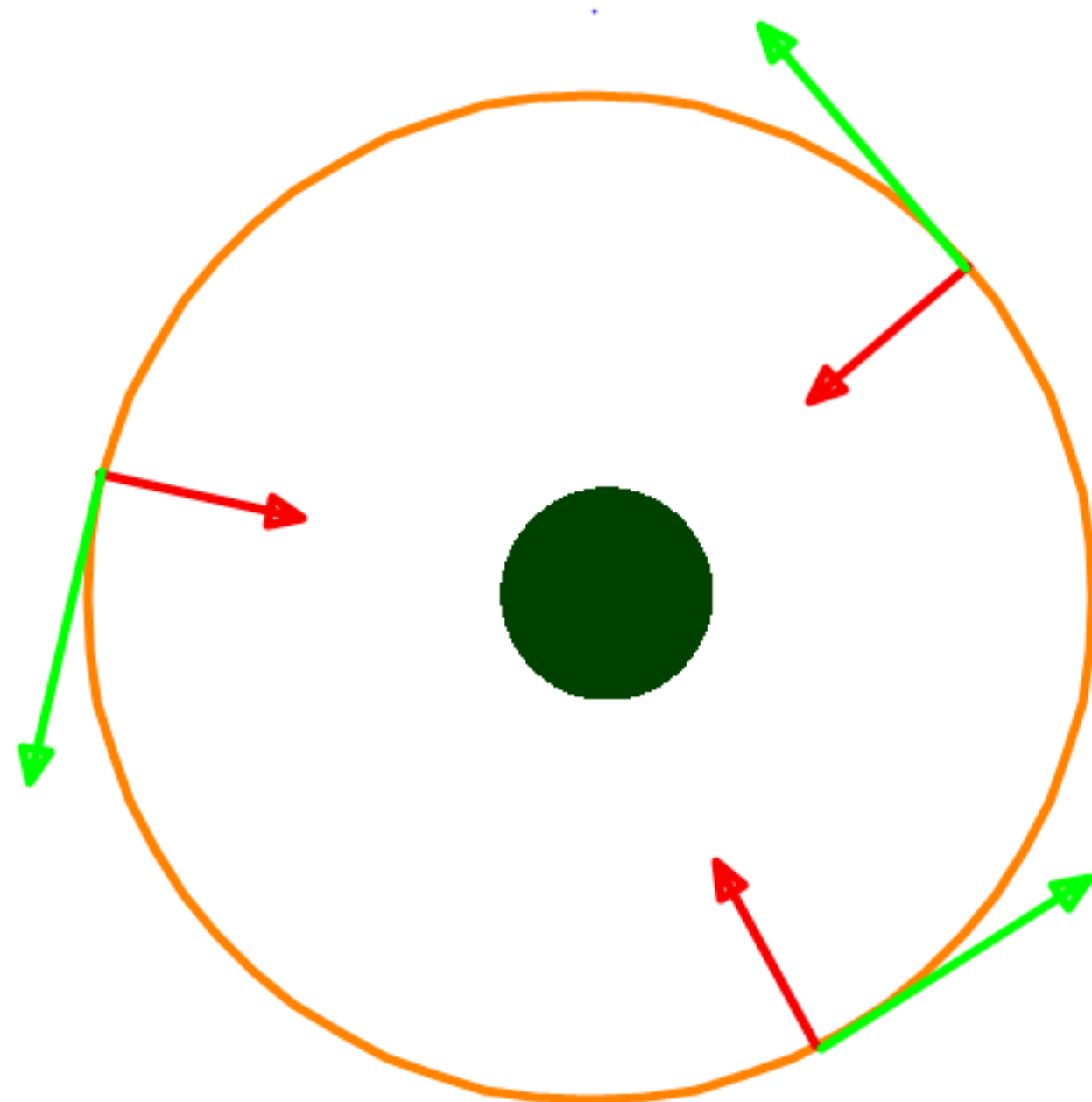
*Apart from **reading the relevant pages from the textbook and solving the rest of the questions in this booklet** your homework is:*

- ✓ Experiment 5 (due Friday)
- ✓ Relevant pages in Multiple Choice Dot Points Book (DPB)
- ✓ New 8 page booklet (pages 16-23)
- ✓ Space 2 Past Year Questions
- ✓ Chapter 3 all questions
- ✓ Experiment 3 of the Practical Booklet
- ✓ Old 8 page booklet (pages 8-15)

NEXT PERIOD > GRAVITATIONAL FORCE

COMPARISON OF COMMON CIRCULAR MOTIONS

MOTION	F_c PROVIDED BY ...
Whirling rock on a string	The string
Electron orbiting atomic nucleus	Electron–nucleus electrical attraction
Car cornering	Friction between tyres and road
Moon revolving around Earth	Moon–Earth gravitational attraction
Satellite revolving around Earth	Satellite–Earth gravitational attraction
Lady bug on a rotating disc	Friction b/w her hairy feet and the disc
Principal rotating the girl in the movie "Mathilda"	Tension in their arms
Playground swing	Tension in the rope
Vortex	Reaction force from the walls
Earth revolving around the Sun	Earth-Sun gravitational attraction



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.