

SPACE

1st Quarter; Module 1

PERIOD 3

Gravitational Potential Energy - E_p

H S C P H Y S I C S																		
SPACE				MOTORS and GENERATORS					From IDEAS to IMPLEMENTATION									
1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	5	6



The Earth has a gravitational field that exerts a force on objects both on it and around it

Students learn to:

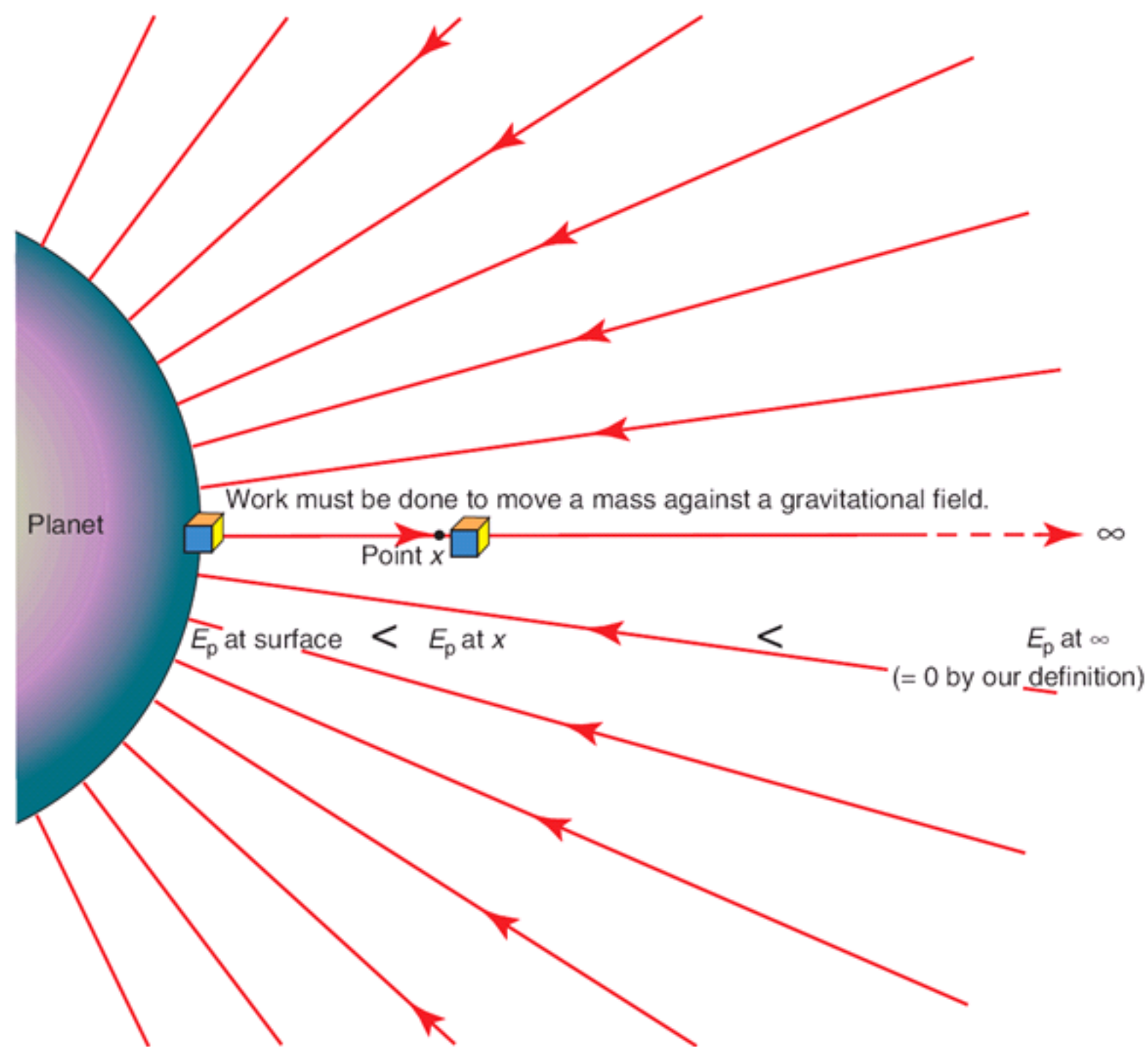
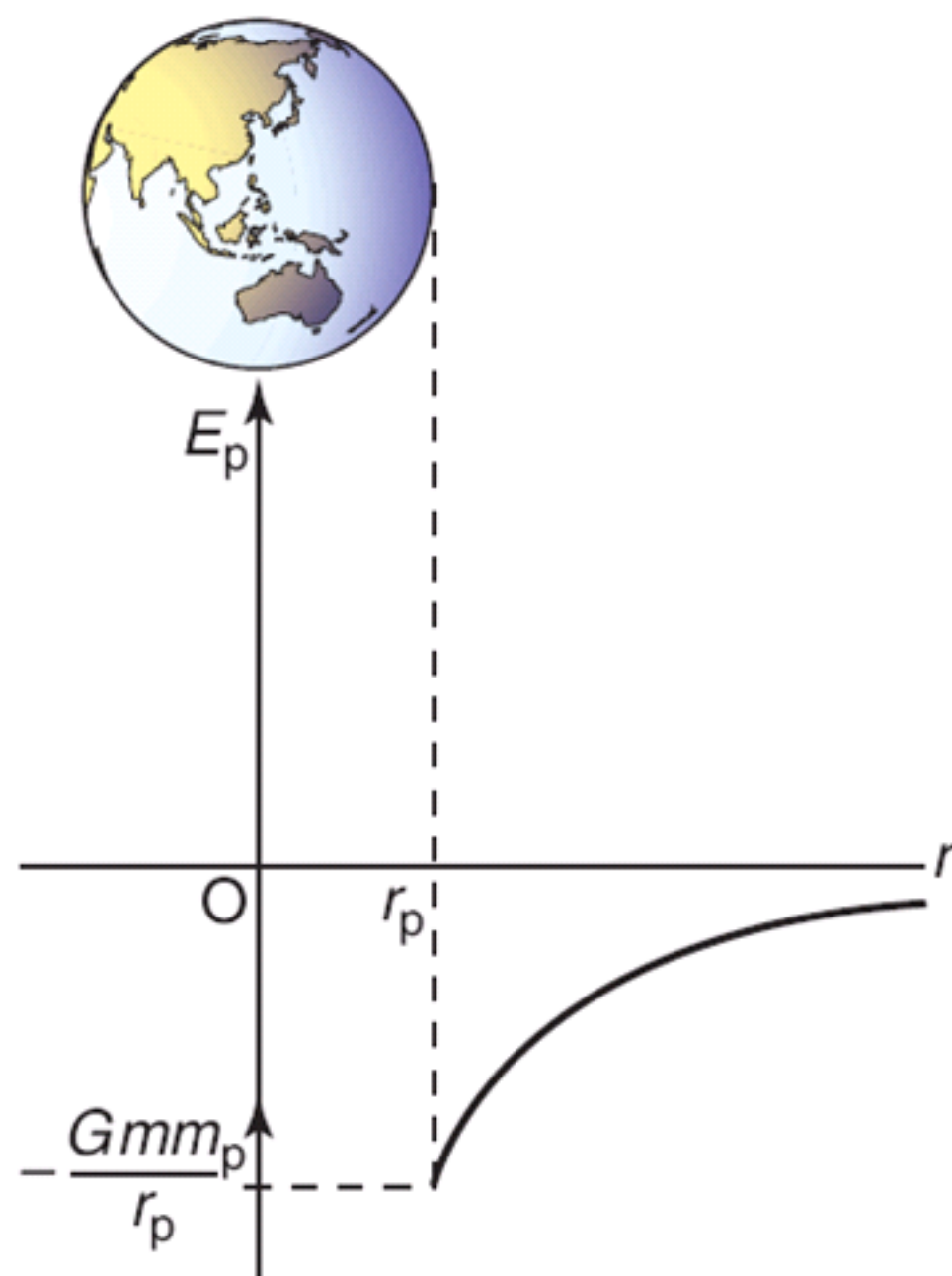
- define weight as the force on an object due to a gravitational field
- explain that a change in gravitational potential energy is related to work done
- define gravitational potential energy as the work done to move an object from a very large distance away to a point in a gravitational field

$$E_p = -G \frac{m_1 m_2}{r}$$

Students:

- perform an investigation and gather information to determine a value for acceleration due to gravity using pendulum motion or computer-assisted technology and identify reasons for possible variations from the value 9.8 m s^{-2}
- gather secondary information to predict the value of acceleration due to gravity on other planets
- analyse information using the expression $F = mg$ to determine the weight force for a body on Earth and for the same body on other planets

GRAVITATIONAL POTENTIAL ENERGY - E_p



1.3

Gravitational potential energy in the Sun–Earth–Moon system

Given the following data, determine the gravitational potential energy of:

- (a) the Moon within the Earth's gravitational field
- (b) the Earth within the Sun's gravitational field.

$$\text{Mass of the Earth} = 5.97 \times 10^{24} \text{ kg}$$

$$\text{Mass of the Moon} = 7.35 \times 10^{22} \text{ kg}$$

$$\text{Mass of the Sun} = 1.99 \times 10^{30} \text{ kg}$$

$$\text{Earth–Moon distance} = 3.84 \times 10^8 \text{ m on average}$$

$$\text{Earth–Sun distance} = 1.50 \times 10^{11} \text{ m on average (one astronomical unit, AU)}$$

E_p and WORK

International Space Station - ISS, launch pad to space!

a) Find the GPE of ISS (150 tonnes), positioned 280 km from the surface of the Earth.

b) How much work needs to be done to increase its orbital radius by 20 km?

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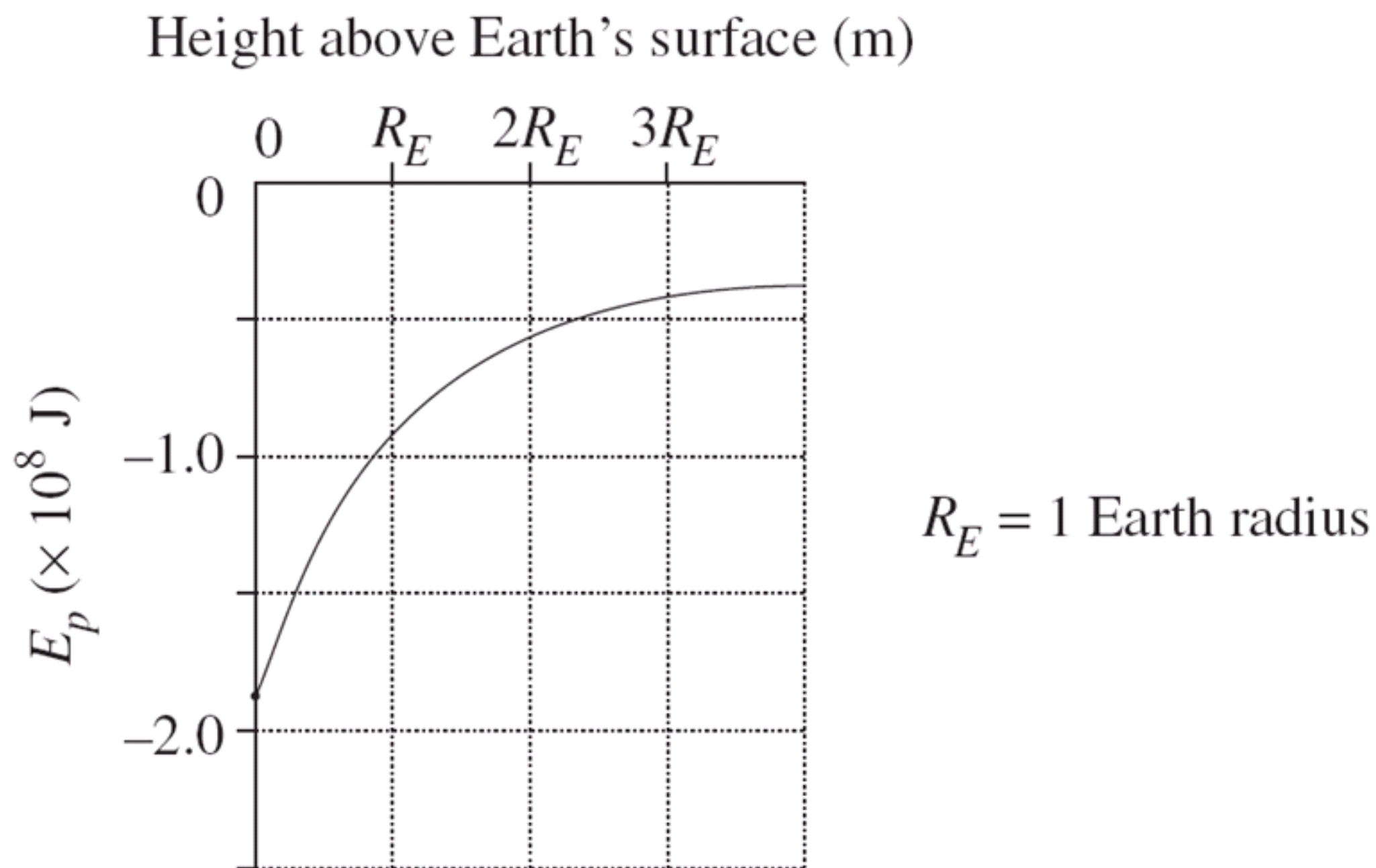
Question 17 (6 marks)

A satellite of mass 150 kg is launched from Earth's surface into a uniform circular orbit of radius 7.5×10^6 m.

- (a) Calculate the magnitude of the gravitational potential energy E_p of the satellite. **1**

Question 17 (5 marks)

The graph below represents the gravitational potential energy (E_p) of a mass as it is raised above Earth's surface.

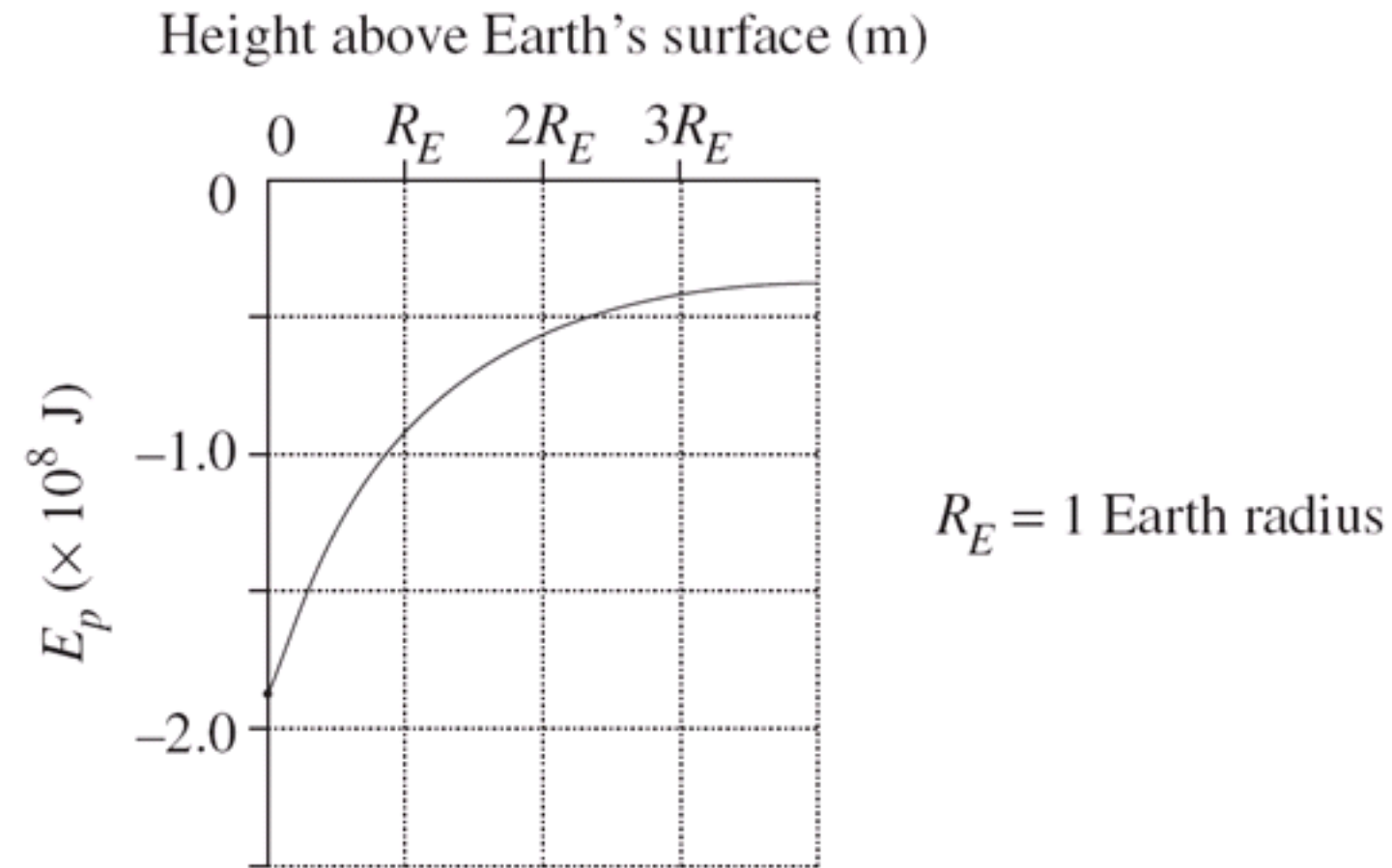


- (a) From the graph, what is the gravitational potential energy of the mass when it is one Earth radius above Earth's surface?

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Question 17 (5 marks)

The graph below represents the gravitational potential energy (E_p) of a mass as it is raised above Earth's surface.



- (b) Use an equation to explain why the graph is a curve and not a straight line.

1

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Question 17 (6 marks)

A satellite of mass 150 kg is launched from Earth's surface into a uniform circular orbit of radius 7.5×10^6 m.

- (b) From this uniform circular orbit, the satellite can escape Earth's gravitational field when its kinetic energy is equal to the magnitude of the gravitational potential energy.

3

Use this relationship to calculate the escape velocity of the satellite.

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Question 18 (3 marks)

An object is stationary in space and located at a distance 10 000 km from the centre of a certain planet. It is found that 1.0 MJ of work needs to be done to move the object to a stationary point 20 000 km from the centre of the planet.

3

Calculate how much more work needs to be done to move the object to a stationary point 80 000 km from the centre of the planet.

What is a planet? Pluto – the tribe has spoken.

In 2002, another world in orbit around our Sun was discovered. Quaoar (Kwah-o-ar) is further out than Pluto, takes 288 years to orbit and is about 1250 km in diameter. Then in 2005, Xena, a similar object but larger than Pluto, was also discovered. Both Xena and Quaoar are ice dwarfs that inhabit the Kuiper belt, a region way beyond the orbit of Neptune. Astronomers have found about 40 of these dwarfs in this region and will probably find many more.

This led to a controversial debate amongst astronomers about whether all these distant ice dwarfs, including Pluto, should be called planets. In 2006, at a meeting of the International Astronomical Union, it was decided that a planet should be large enough to become spherical under its own gravity and should be large enough to dominate the region. Pluto failed this test because its moon Charon is almost as large as Pluto. Xena, Quaoar, Charon and Pluto are now officially classified as dwarf planets.

Table 3.4 Data for the Sun, its eight planets and Earth's Moon

Body	Mass (kg)	Radius (m)	Period of rotation	Mean orbital radius (m)	Period of orbit	Av. orbital speed (km s ⁻¹)
Sun	1.98×10^{30}	6.95×10^8	24.8 days	NA	NA	NA
Mercury	3.28×10^{23}	2.57×10^6	58.4 days	5.79×10^{10}	88 days	47.8
Venus	4.83×10^{24}	6.31×10^6	243 days	1.08×10^{11}	224.5 days	35.0
Earth	5.98×10^{24}	6.38×10^6	23 h 56 min	1.49×10^{11}	365.25 days	29.8
Mars	6.37×10^{23}	3.43×10^6	24.6 h	2.28×10^{11}	688 days	24.2
Jupiter	1.90×10^{27}	7.18×10^7	9.8 h	7.78×10^{11}	11.9 years	13.1
Saturn	5.67×10^{26}	6.03×10^7	10 h	1.43×10^{12}	29.5 years	9.7
Uranus	8.80×10^{25}	2.67×10^7	10.8 h	2.87×10^{12}	84.3 years	6.8
Neptune	1.03×10^{26}	2.48×10^7	15.8 h	4.50×10^{12}	164.8 years	6.5
Moon	7.34×10^{22}	1.74×10^6	27.3 days	3.8×10^8	27.3 days	1.0

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. Chapter 1 questions - ALL
2. Investigation 2 of the "Practical Booklet" [due Monday]
3. Study "CSU Space 1 Notes"
4. Study experiment - page 11



1.1 USING A PENDULUM TO DETERMINE g

Aim

To determine the rate of acceleration due to gravity using the motion of a pendulum.

NEXT PERIOD >

FINDING "g" IN SULE COLLEGE

(by using nothing but a ruler, a stopwatch, string and some masses)

