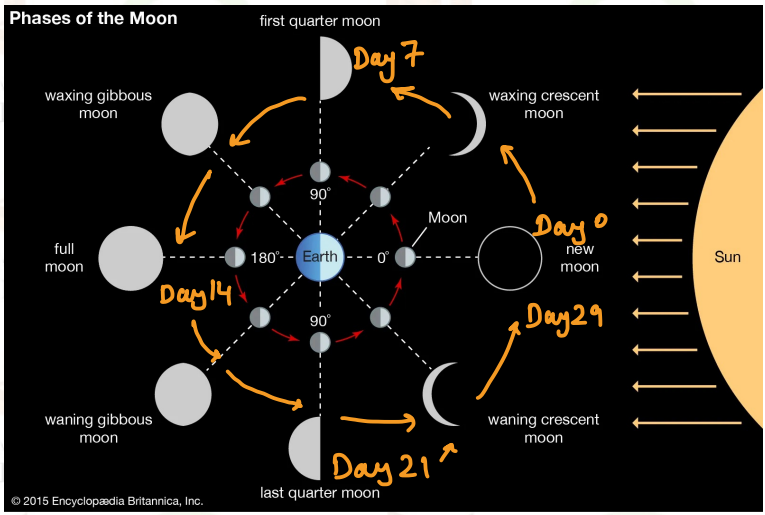
Moon and Earth

The Moon is a natural satellite that
- orbits the earth in a roughly circular orbit.
- takes about one month to complete one orbit.
- rotates on its axis once every 28 days so the same side always faces the earth

Phases of the moon

- The Moon doesn't produce its own light.
- It is visible in the night sky because it reflects light from the sun.
- As it orbits around the earth, it goes through different phases.



Day 0 New Moon is observed.

- Moon is positioned between the earth and the sun.
- the side facing the earth is dark, side facing away from earth is illuminated.

Day 7 First Quarter is observed

- After the new moon, a waxing crescent is formed.
- After the first quarter moon, it continues to brighten (wax) into a gibbous shape.

Day 14 Full moon is observed.

- The earth is positioned between the moon and the sun.
- The side of the moon facing the earth is fully illuminated.
- All of the moon's surface is visible.

Day 21 Last Quarter is observed

- After the full moon, the moon becomes dimmer (wanes) back into a gibbous shape.
- After the last quarter, it continues to dim to a crescent. (Waning crescent)

Day 29 New Moon

A new moon is formed and cycle starts again.

Note: https://www.youtube.com/watch?v=qdOHRttkKLE

- The Moon revolves around its own axis in a month, the same time it takes to travel around the earth, hence always has the same side facing the earth.

10 (a) Fig. 10.1 represents different positions A–H of the Moon as it rotates around the Earth.

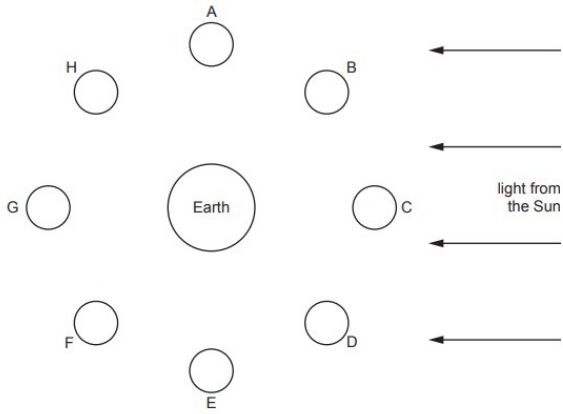


Fig. 10.1

(i) State a position of the Moon where an observer on Earth sees:

1. there is a quarter Moon  .....

2. there is a full Moon  .....

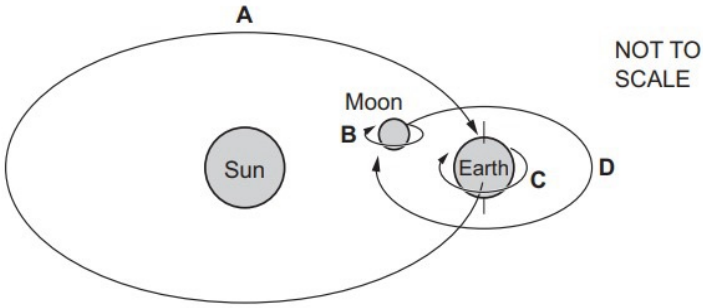
[2]

(ii) State the approximate time taken for the Moon to orbit the Earth.

time = ... [1]

A student draws a simplified diagram showing the Sun and the different movements of the Moon and the Earth.

Which arrow represents a motion taking 365 days to complete?



The Earth is a planet that orbits the Sun once in approximately 365 days.

What does this enable us to explain?

A the cycle of day and night

B the cycle of phases of the moon

C the periodic nature of the seasons

D the apparent daily motion of the Sun

What is the cause of the phases of the Moon?

A the movement of the Earth around the Sun

B the movement of the Moon around the Sun

C the movement of the Moon around the Earth

D the movement of the Sun around the Moon

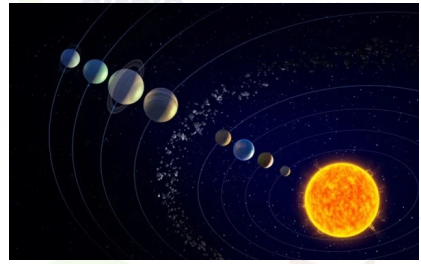
Which row explains the apparent daily motion of the Sun across the sky and the cycle of phases of the Moon?

	the daily motion of the Sun across the sky	the cycle of phases of the Moon
A	the Earth rotates on its axis once every 24 hours	the Earth orbits the Sun once approximately every 365 days
B	the Earth rotates on its axis once every 24 hours	the Moon orbits the Earth approximately once every month
C	the Moon orbits the Earth approximately once every month	the Earth orbits the Sun once approximately every 365 days
D	the Moon orbits the Earth approximately once every month	the Earth rotates on its axis once every 24 hours

The Solar System

The Solar System consists of:

- The Sun
- Eight planets
- Natural and artificial satellites
- Dwarf planets
- Asteroids and comets



The Planets

There are eight planets which orbit the sun, in ascending order of the distance from the sun, these are: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.

The planets can be divided into two groups:

- the inner rocky planets
- the outer gas giants.

Dwarf Planets

- A dwarf planet is an object similar to a planet, but much smaller.
- The gravitational field around a planet is strong enough to pull in nearby objects.
- Whereas, the gravitational field around a dwarf planet is not strong enough to pull in nearby objects.

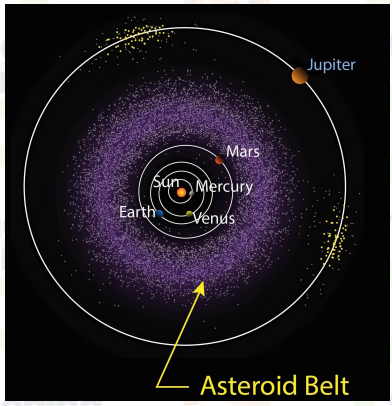
Satellites

There are two types of satellites: natural and manmade.

- Natural satellites are objects that orbit planets.
- A moon is a type of natural satellite.
- Artificial satellites are manmade objects that orbit another object in space.
- The ISS (international space station) is an example of an artificial satellite that orbits the earth.

Asteroids and comets

- Asteroids and comets also orbit the sun.
- Asteroids are found in the asteroid belt between Mars and Jupiter, whereas comets are usually found in the outer reaches of the solar system due to their highly elliptical orbits.

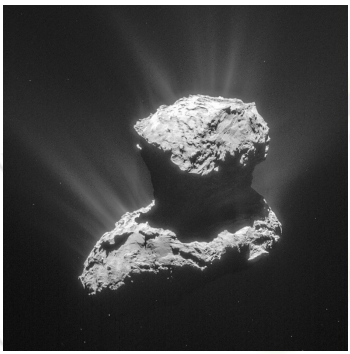


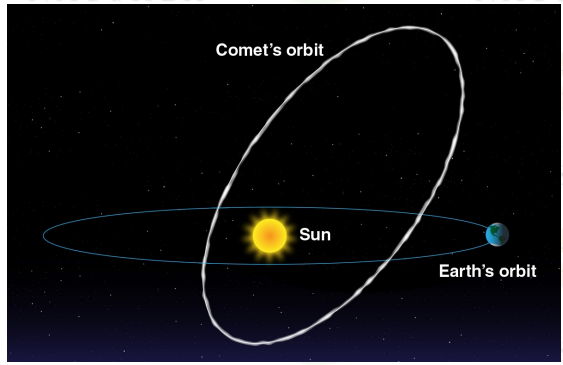
Asteroid

A small rocky object that orbits the sun.

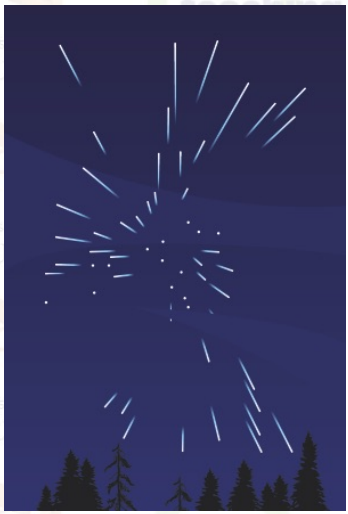
Comet

- A comet is an object made up of dust and ice which orbits the sun in a highly elliptical path
- The ice turns to gas in the suns heat, causing a jet of gas to burst out of the comet, which forms the comet's tail.





Note:
A meteor is what happens when a small piece of an asteroid or comet, called a meteoride, burns up upon entering the earth's atmosphere, creating a streak of light in the sky.



https://www.youtube.com/watch?v=x1QTc5YeO6w

Formation of the solar system

The 4 inner planets (nearest to the sun):

- are rocky and small.
- have atmospheres (except for Mercury)

The 4 outer planets (furthest from the sun)

- are gaseous and large
- are mostly composed of hydrogen and helium gas.

The differences between the inner and outer planets can be explained using the accretion model for the formation of the solar system.

Distribution of elements in the solar system

The sun and planets in the solar system are formed from a cloud of dust and gas (nebula).

- Gravity pulled this cloud together into a giant ball, which would eventually become the sun.
- As the nebula collapsed, the sun became denser and hotter.
- The remnants of the nebula formed the planets around the sun
- The nebula contained many elements that were created during a supernova explosion in the past.

- As the sun became hotter, the gaseous matter was pushed further out into the solar system than solid matter.

Formation of the inner planets

- In the hotter regions, closer to the sun, the temperature was too high for lighter elements to exist in a solid state.
- Hence inner planets formed from elements with high melting temperatures.
- Since proportion of the heavy elements was less in the original nebula, hence the planets formed were less massive.
- Therefore solids in the inner disc were pulled together by gravity to form solid planets.

Formation of the outer planets

- In the cooler regions, further from the sun, the temperature was low enough for the lighter molecules to exist in a solid state.
- The cold temperature allowed ice and gas to accumulate.
- Therefore outer planets were formed from materials with low melting temperatures.
- Since the proportion of light elements was large in the original nebula, hence the outer planets were exceptionally large.
- Therefore gases in the outer disc were pulled together

by gravity to form gaseous planets.

Formation of the accretion disc

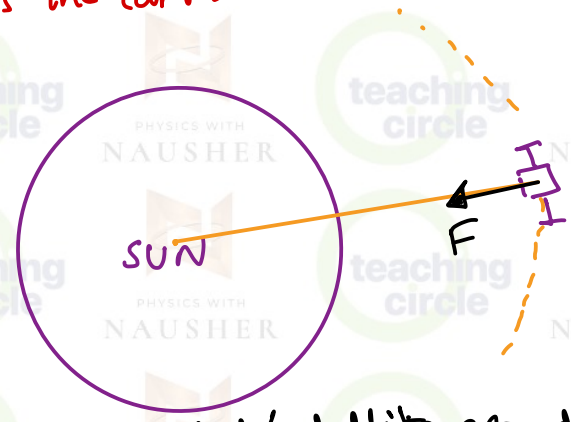
- Gradual collection of matter in the nebula because of gravitational forces.
- As the cloud of dust and gas collapsed due to attractive forces,
  - → the cloud began to spin faster
  - → became hotter
  - → formed an accretion disc
- From the rotating disc, the sun and planets emerged
  - → sun at the center
  - → planets in the disc (rocky closer, gaseous away)

Orbitting bodies

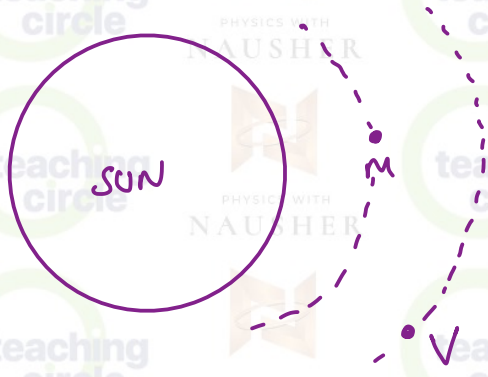
The solar system is made up of many bodies which orbit around other bodies.

Smaller masses orbit the larger masses.

e.g planets orbit the sun
moon orbits the earth.



- The force that keeps an object/satellite around the sun is the gravitational attraction of the sun.
- The gravitational force is proportional to gravitational field of the sun.
- As distance from the sun increases, the gravitational field decreases.



a) Which planet experiences greater gravitational force of the sun?

M

b) How does M maintain its orbit although it should be pulled towards the sun since it is the closest. Comment with regards to orbital velocity.

since distance is less, it experiences greater gravitational attraction.

Data Analysis:

Data for the planets in the Solar System

Planet	Mean distance from Sun (relative to Earth)	Orbital period (Earth years)	Mean surface temperature (°C)	Density (kg/m^3)	Diameter (10^3 km)	Mass (relative to Earth)	Surface gravity (N/kg)	Number of moons
Mercury	0.39	0.24	350	5429	4.9	0.06	3.7	0
Venus	0.72	0.60	460	5243	12.1	0.82	8.9	0
Earth	1	1	20	5514	12.8	1	9.8	1
Mars	1.5	2	-23	3934	6.8	0.11	3.7	2
Jupiter	5.2	12	-120	1326	143	320	23.1	63
Saturn	9.6	30	-180	687	121	95	9.0	61
Uranus	19	84	-210	1270	51	15	8.7	27
Neptune	30	160	-220	1638	50	17	11.0	13

Comparisons:

- Neptune is 30 times more distant from the sun as compared to the earth.
- Jupiter contains the same mass as 320 earths.
- Mars orbital period is twice of earth.

Trends:

- As distance from the sun increases, the time to orbit also increases, the mean surface temperature decreases (except for Venus, an anomaly).

Q. State and explain the relationship between the distance of a planet from the sun and its

a) surface temperature.

As distance from the sun increases, the intensity of light decreases hence, the surface temperature of the planets decreases.

b) orbital period

As distance increases, the force of gravity on the planets decreases. Hence orbital velocity decreases and circumference of orbit increases. orbital time period increases

c) density

Due to the high temperature of the sun's light elements cannot exist close to the sun. Hence the heavier elements which form rocky planets with high density exist close to the sun. As distance from the sun increases, the temperatures decrease, hence light elements form ice and gas giants of low density at much greater distances.

Prediction:

- The temperature of a dwarf planet in an asteroid belt would be between $-23°C$ and $-120°C$

Note:

The dark space around the earth is a result of the absence of scattering and diffusion that we experience in our atmosphere. Light is only visible when it reflects off objects. In the vacuum of space, there is nothing to scatter/reflect light.

11 Fig. 11.1 represents the four planets nearest to the Sun.

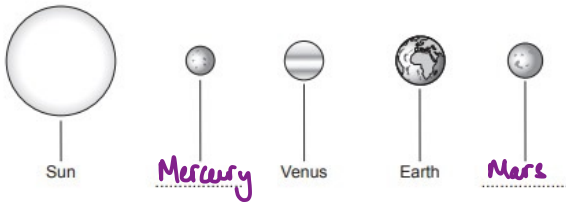


Fig. 11.1 (not to scale)

(a) Two of the planets in Fig. 11.1 are not labelled. On each dotted line, write the name of the planet.

[2]

(b) The distance of Venus from the Sun is 1.1×10^{11} m. The speed of light is 3.0×10^{8} m/s.

Calculate the time it takes light to travel from the Sun to Venus.

$v = \frac{d}{t}$

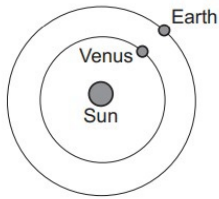
$3.0 \times 10^{8} = \frac{1.1 \times 10^{11}}{t}$

$t = 367$

time taken = 370 s [3]

38 The radius of the orbit of Venus around the Sun is 110×10^{6} km.

The radius of the orbit of the Earth around the Sun is 150×10^{6} km.



The speed of light is 0.30×10^{6} km/s.

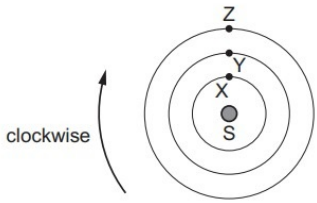
How long does light take to travel from Venus to the Earth when these planets are closest to each other?

A 130 s **B** 370 s **C** 500 s **D** 870 s

$v = \frac{d}{t}$

$0.3 \times 10^{6} = \frac{40 \times 10^{6}\ \text{km}}{t}$

38 The diagram shows a star S and the initial arrangement of three planets, X, Y and Z.



NOT TO SCALE

X	Y	Z
T	3T	6T

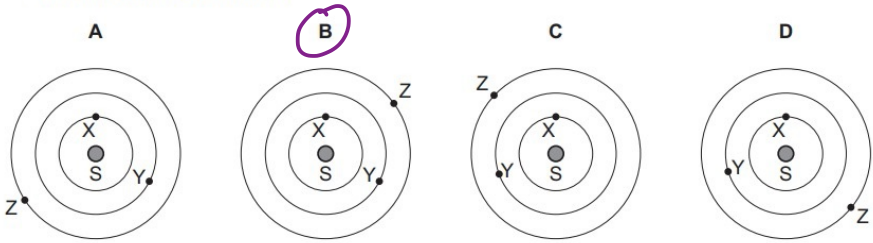
Each planet orbits clockwise in a circle about S.

The time for one orbit of Y is three times the time taken for one orbit of X.

The time for one orbit of Z is twice the time taken for one orbit of Y.

Starting from the initial arrangement, which diagram shows the positions of the planets after X has made one complete orbit?

A B C D



Gravitational field

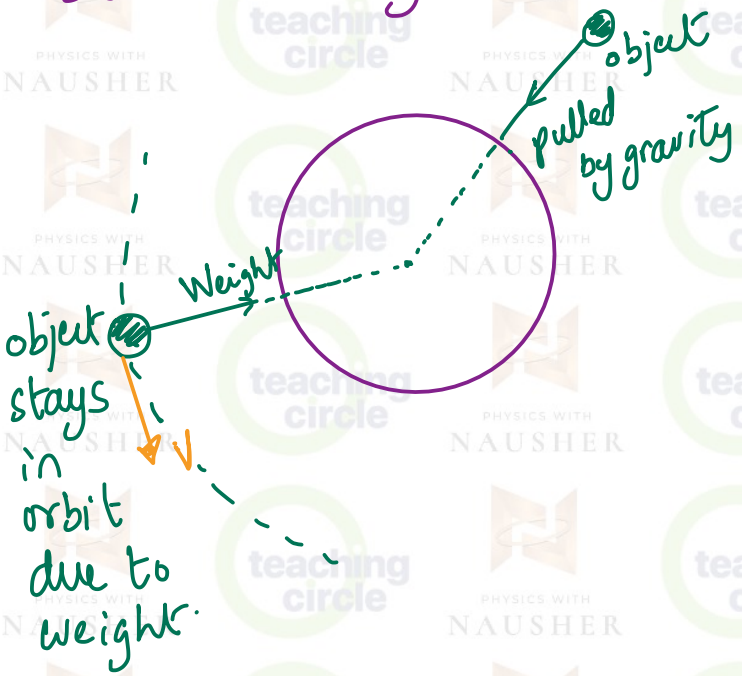
Strength of gravity on different planets causes the weight of an object to vary on each planet.

Weight is defined as the force acting on an object due to gravitational attraction

Planets have strong gravitational fields hence they attract nearby masses with a strong gravitational force.

Because of weight

- objects are always pulled to the ground
- satellites stay in orbit.



Note:

① Weight = mg

m: mass → constant

g: gravitational field.

Weight ∝ gravitational field

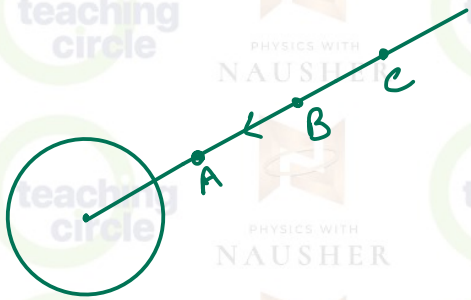
On the moon, the weight of the object is less as compared to earth

Note: close to the surface of any planets, the gravitational field is constant and does not vary. e.g $9.81 ms^{-2}$ on earth has very little variation no matter where you are.

② gravitational field $\propto$ Mass of planet

The more the mass of the planet, the greater the gravitational field.

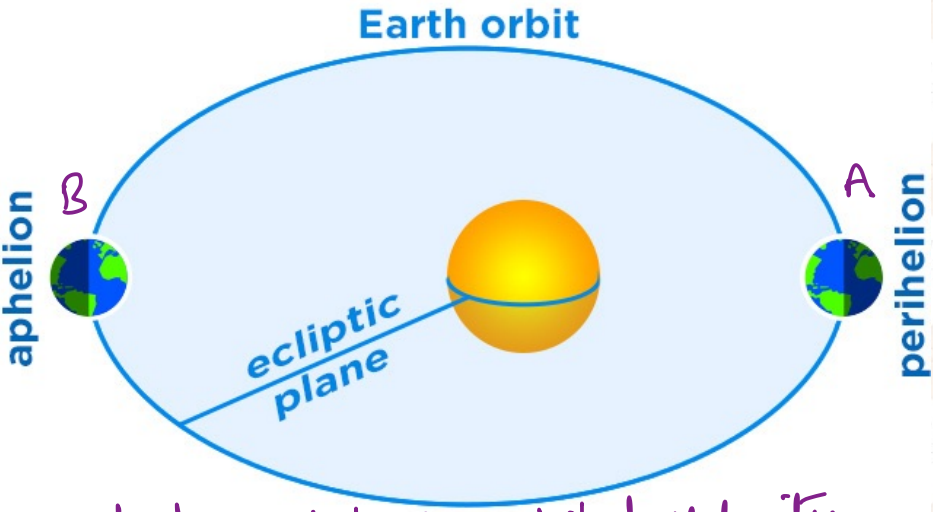
③ gravitational field $\propto \frac{1}{\text{distance from the planet}}$



At C, gravitational field is weakest.

④ gravitational field on Jupiter is the highest, meaning object weighs the most on Jupiter as compared to any other planet.

(5)



At which point is orbital velocity greater? Explain with reference to energy conservation.

$V_A > V_B$. Force of gravity is greater. Total Energy = Kinetic energy + Potential Energy. At A, GPE decreases since distance between sun and earth decreases, hence KE at A increases.

Note: The sun contains most of the mass of the solar system and hence gravitational field on surface of sun is the strongest compared to any of the planets. Hence:

- planets orbit the sun.
- the force is directed from the orbiting objects to the center of the sun.

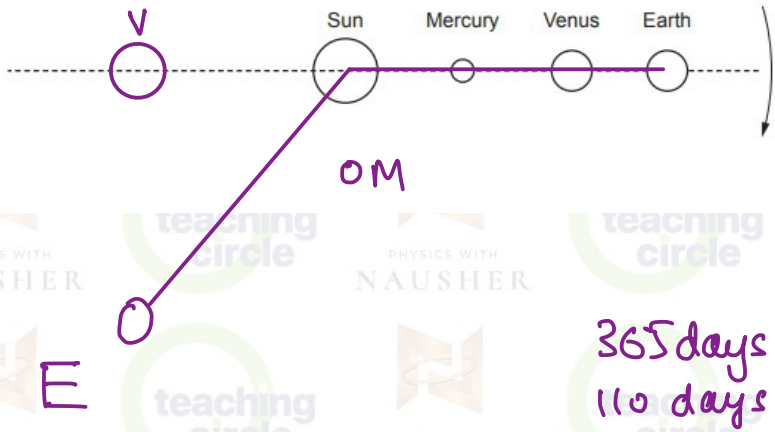
8 Table 8.1 shows data about three planets, Mercury, Venus and Earth.

Table 8.1

	time for one orbit of Sun/days	distance from Sun/km	average density / kg/m^3	gravitational field strength at surface / N/kg
Mercury	88	5.8×10^7	5400	3.7
Venus	220	1.1×10^8	5200	8.9
Earth	365	1.5×10^8	5500	9.8

(a) Fig. 8.1 shows these planets in alignment with the Sun. They rotate around the Sun in the direction shown.

Mark and label on Fig. 8.1 the positions of the three planets 110 days after the position shown in Fig. 8.1.



365 days – 1 circle
110 days – x
x = 0.3

(b) (i) Each of the three planets has a similar average density.

Suggest why the gravitational field strength at the surface of Mercury is much smaller than at the surface of Venus.

mass of mercury is much smaller.

..... [1]

(ii) An object has a weight of 37 N on the surface of Mercury.

Calculate its weight on the surface of the Earth. Show your working.

$W = mg$

$m = \frac{37}{3.7} = 10$

$W = mg = 10 \times 9.8$

98

weight = ... N [2]

9 The planet Venus orbits the Sun at a constant speed of 3.5×10^4 m/s and takes a time T_V to complete one orbit.

(a) Venus is always 1.1×10^{11} m from the Sun.

Calculate T_V.

$T = \frac{2\pi R}{V} = \frac{2\pi \times 1.1 \times 10^{11}}{3.5 \times 10^4} = 1.97 \times 10^7$

T_V = 2.0×10^7 s [2]

(d) One planet in the Solar System is closer to the Sun than Venus.

(i) State the name of this planet.

mercury

..... [1]

(ii) Compare the time that this planet takes to complete one orbit of the Sun with T_V and explain the difference.

it takes less time because the force of gravity is stronger, hence it has greater orbital velocity. The circumference of the orbit is less, hence it takes less time than T_V. [2]