Key

**Gravitational Force Field**

**1.** This question is about gravitation and ocean tides.

(a) State Newton's law of universal gravitation.

Force of attraction calculated to be proportional to the product of the two masses and inverse to the square of the distance between them

**(2)**

(b) Use the following information to deduce that the gravitational field strength at the surface of the Earth is approximately 10 N kg$^{-1}$.

Mass of the Earth = $6.0 \times 10^{24}$ kg

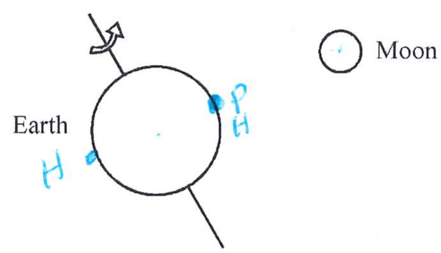
Radius of the Earth = 6400 km

$$g = \frac{GM}{r^2} = \frac{(6.67\times10^{-11})(6\times10^{23}\,kg)}{(6.4\times10^{6}\,m)}$$

$= 9.8 \frac{N}{kg}$

**(2)**

The Moon's gravitational field affects the gravitational field at the surface of the Earth. A high tide occurs at the point where the resultant gravitational field due to the Moon and to the Earth is a minimum.




(c) (i) On the diagram above label, using the letter P, the point on the Earth's surface that experiences the greatest gravitational attraction due to the Moon. Explain your answer.

Point on earth that is closest to the moon.

**(2)**

(ii) On the diagram above label, using the letter H, the location of a high tide. Explain your answer.

?

......................................................................................................................

**(2)**

(iii) Suggest **two** reasons why high tides occur at different times of the day in different locations.

Sun also has impact. Moon orbits the Earth

**(2)**

**(Total 10 marks)**

**2.** This question is about gravitational fields.

(a) Define *gravitational field strength*.

Force per unit mass; Force on a tiny point mass

**(2)**

The gravitational field strength at the surface of Jupiter is 25 N $kg^{-1}$ and the radius of Jupiter is $7.1 \times 10^7$ m.

(b) (i) Derive an expression for the gravitational field strength at the surface of a planet in terms of its mass *M*, its radius *R* and the gravitational constant *G*.

$F = mg$ so $g = \frac{F}{m}$ · $mg = \frac{GMm}{r^2}$ $g = \frac{GM}{r^2}$

**(2)**

(ii) Use your expression in (b)(i) above to estimate the mass of Jupiter.

$M = \frac{gr^2}{G} = \frac{(25\frac{N}{kg})(7.1 \times 10^7 m)^2}{(6.67 \times 10^{-11})} = 1.9 \times 10^{27}$ kg

**(2)**

**(Total 6 marks)**

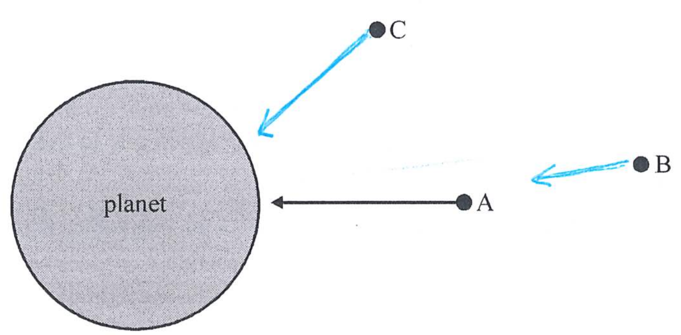
**3.** This question is about gravitation and orbital motion.

(a) Define *gravitational field strength* at a point in a gravitational field.

Force per unit mass; Force on a tiny point mass

**(2)**

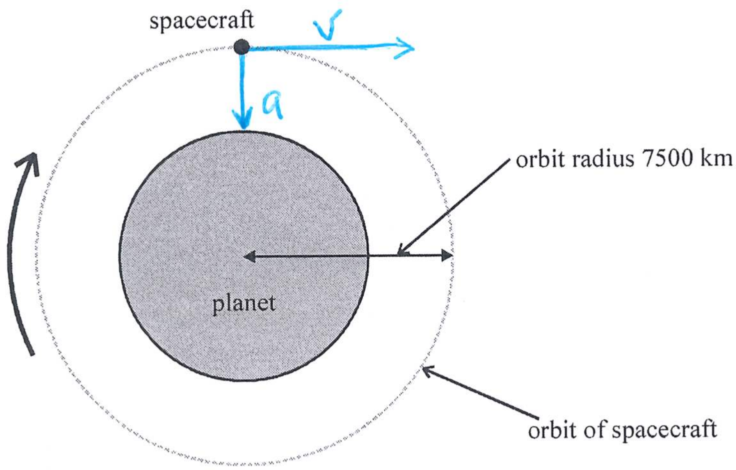
The diagram below shows three points above a planet. The arrow represents the gravitational field strength at point A.




(b) Draw arrows to represent the gravitational field strength at point B and point C.

**(2)**

A spacecraft is in a circular orbit around the planet as shown in the diagram below. The radius of the orbit is 7500 km.




(c) For the spacecraft in the position shown, draw and label arrows representing

(i) the velocity (label this arrow V). **(1)**

(ii) the acceleration (label this arrow A). **(1)**

The speed of the spacecraft is 6.5 km $s^{-1}$.

(d) Deduce the value of the magnitude of the gravitational field strength at a point in the spacecraft's orbit.

$a = \frac{v^2}{r} = \frac{(6{,}500\ m/s)^2}{(7.5 \times 10^6\ m)} = \boxed{5.6\ \frac{N}{kg}}$

**(3)**

**(Total 9 marks)**