1. A satellite orbits at a height h above the Earth's surface. Let R be the Earth's radius. If V_e is the escape velocity and V_o is the orbital velocity of the satellite orbiting at a height $h << R$, then

- (selected) $V_e = 2 V_o$ ✗
- $V_e = V_o$
- $V_e^2 = 2 V_o^2$ ✓
- $V_o^2 = 2 V_e^2$

Explanation:

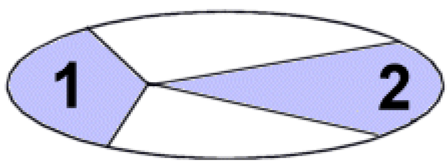
The escape velocity and the orbital velocity for a satellite are given by

$$V_e = \sqrt{2gR}$$

$$V_o = \sqrt{\frac{gR^2}{R+h}}$$

The expression for the case where $h << R$ can be obtained by putting $h = 0$ in the equation for the orbital velocity. The relationship $V_e^2 = 2 V_o^2$ can then be readily obtained.

2.



The figure shows the elliptical orbit of a planet with the Sun at the focus. The areas of regions 1 and 2 are the same. If the planet takes times t_1 to go from one end to the other end of region 1 and t_2 to go from one end to the other end of region 2, then what is the relationship between t_1 and t_2?

- Cannot be determined
- $t_1 > t_2$
- (selected) $t_1 < t_2$ ✗
- $t_1 = t_2$ ✓

Kepler's second law states that the radius vector from the sun to the planet sweeps equal areas in equal intervals of time. Hence $t_1 = t_2$.

3. If a simple pendulum with a time period of 5 seconds is made to oscillate at a height R equal to the Earth's radius, then its time period at this height will be

- 10 s ✓
- (selected) 5 s ✗
- 1 / 5 s
- 1 / 10 s

Explanation:
The acceleration due to gravity at a height *R* above the surface of the Earth is given by

$$g_R = \frac{GM}{(R+R)^2} = \frac{GM}{4R^2} = \frac{g}{4}$$

The time period of the pendulum at this height is

$$T_R = 2\pi\sqrt{\frac{L}{g_R}} = 2\pi\sqrt{\frac{L}{g}} \times \sqrt{4} = 2T$$

Substituting $T = 5$, the time period is found to be 10 s.

4. Two planets of radii R_1 and R_2 have the same density. The ratio of their accelerations due to gravity at the surface is

- (selected) $(R_1/R_2)^2$ ✗
- R_2/R_1
- $(R_2/R_1)^2$
- R_1/R_2 ✓

Explanation:
The acceleration due to gravity is given by

$$g = \frac{GM}{R^2}$$

Since the planets have the same density, the mass *M* is proportional to the cube of the radius. The acceleration due to gravity *g* is therefore proportional to the radius *R*.

5. Two satellites of masses M_1 and M_2 have escape velocities V_1 and V_2 from the surface of a planet of radius *R* with acceleration due to gravity *g*. Which of the following is true?

- $V_1 = V_2$ ✓
- $V_1 / V_2 = M_1 / M_2$
- (selected) $V_1 / V_2 = (M_2 / M_1)^2$ ✗
- $V_1 / V_2 = M_2 / M_1$

Explanation:
The formula for the escape velocity is

$$v_e = \sqrt{2gR}$$

Clearly, the escape velocity is independent of the mass of the satellite. It depends only on the radius of the planet and the acceleration due to gravity. So $V_1 = V_2$.

1. Two planets of radii R_1 and R_2 have the same density. The ratio of their accelerations due to gravity at the surface is

- ○ $(R_2/R_1)^2$
- ○ R_2/R_1
- ◉ R_1/R_2 ✓
- ○ $(R_1/R_2)^2$

Explanation:
The acceleration due to gravity is given by

$$g = \frac{GM}{R^2}$$

Since the planets have the same density, the mass *M* is proportional to the cube of the radius. The acceleration due to gravity *g* is therefore proportional to the radius *R*.

2. An Earth satellite of mass *m* revolves at a height *h* from the surface of the Earth. If *R* is the Earth's radius and *g* is the acceleration due to gravity at the surface of the Earth, then the velocity of the satellite is given by

- ○ $\sqrt{\frac{gR^2}{R+h}}$ ✓
- ○ $\frac{gR^2}{R+h}$
- ○ $\frac{gR}{R+h}$
- ◉ $\sqrt{\frac{gR}{R+h}}$ ✗

Explanation:
A force balance on the satellite gives

$$\frac{GMm}{(R+h)^2} = \frac{mv^2}{R+h}$$

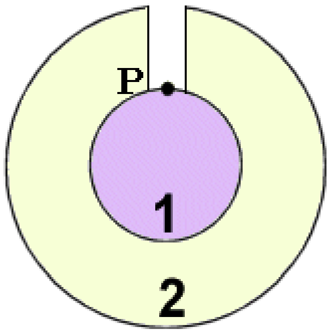
Canceling the common terms and simplifying,

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

On rearranging, the velocity of the satellite is found to be

$$v = \sqrt{\frac{GM}{R^2} \times \frac{R^2}{R+h}} = \sqrt{\frac{gR^2}{R+h}}$$

3.



Consider a hole drilled into the Earth and an object placed at the bottom of the hole (point P) as shown in the figure. The gravitational force of attraction on the object will be due to

- ○ region 1 and a portion of region 2
- ○ regions 1 and 2
- ○ region 2
- ● region 1 ✓

The force with which the object is attracted is just due to region 1. The force due to region 2 gets canceled totally. So the total force acting on the object is due to region 1 only.

4. If the radius of the Earth were increased by a factor of 3 and its mass remained the same, then the acceleration due to gravity on the Earth would

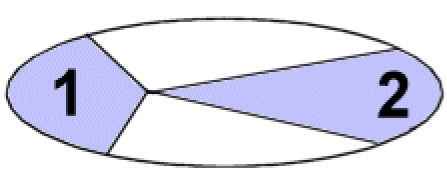
- ○ increase by a factor of 3
- ● reduce by a factor of 3 ✗
- ○ increase by a factor of 9
- ○ reduce by a factor of 9 ✓

Explanation:
The acceleration due to gravity can be expressed as

$$g = \frac{GM}{R^2}$$

If the mass *M*of the Earth remains constant and the radius *R* were increased by a factor of 3, then the acceleration *g* would reduce by a factor of 9 .

5.

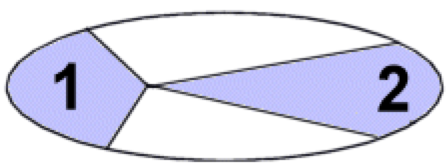


The figure shows the elliptical orbit of a planet with the Sun at the focus. The areas of regions 1 and 2 are the same. If the planet takes times t_1 to go from one end to the other end of region 1 and t_2 to go from one end to the other end of region 2, then what is the relationship between t_1 and t_2?

- $t_1 > t_2$
- Cannot be determined ✗
- $t_1 < t_2$
- $t_1 = t_2$ ✓

Kepler's second law states that the radius vector from the sun to the planet sweeps equal areas in equal intervals of time. Hence $t_1 = t_2$.

1.



The figure shows the elliptical orbit of a planet with the Sun at the focus. The areas of regions 1 and 2 are the same. If the planet takes times t_1 to go from one end to the other end of region 1 and t_2 to go from one end to the other end of region 2, then what is the relationship between t_1 and t_2?

- $t_1 > t_2$
- $t_1 = t_2$ ✓
- Cannot be determined
- $t_1 < t_2$

Kepler's second law states that the radius vector from the sun to the planet sweeps equal areas in equal intervals of time. Hence $t_1 = t_2$.

2. Two planets of radii R_1 and R_2 have the same density. The ratio of their accelerations due to gravity at the surface is

- $(R_2 / R_1)^2$
- R_1 / R_2 ✓
- R_2 / R_1
- $(R_1 / R_2)^2$

Explanation:
The acceleration due to gravity is given by

$$g = \frac{GM}{R^2}$$

Since the planets have the same density, the mass *M* is proportional to the cube of the radius. The acceleration due to gravity *g* is therefore proportional to the radius *R*.

3. The ratio of the time periods for two satellites of equal mass in circular orbits of radii *R* and 4 *R* is

○ 1 : 4 ● 4 : 1 ✗ ○ 1 : 8 ✓ ○ 8 : 1

Explanation:

For two satellites of equal mass in circular orbits of radii R_1 and R_2,

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

The above equation is merely Kepler's third law as applied to satellites in circular orbits. Substituting R_1 = *R* and R_2 = *R*, the ratio of the time periods turns out to be 1 : .

4. If the escape velocity of a rocket from the surface of the Earth is v_e , then the escape velocity of the same rocket from the surface of a planet whose acceleration due to gravity as well as radius are 4 times that of the Earth is

○ 4 v_e ✓ ● 16 v_e ✗ ○ v_e / 4 ○ v_e

Explanation:

The escape velocity of an object from the surface of a planet of radius *R* and acceleration due to gravity *g* is given by

$$v_e = \sqrt{2gR}$$

Increasing both *g* and *R* by a factor of 4 will result in the escape velocity increasing by a factor of 4. So, the answer is 4 v_e.

5. If the value of gravitational acceleration at a height *h* above the Earth's surface is the same as that at a depth *d* below the Earth's surface (with both *h* and *d* small compared to the Earth's radius *R*), then

○ $h = d$ ● $h = d^2 / R$ ✗ ○ $h = d / 2$ ✓ ○ $h = 2d$

Explanation:

The expression for *g* at a height *h* above and a depth *d* below the surface of Earth for $h << R$ and

$d << R$ are

$$g_h = g\left(1 - \frac{2h}{R}\right)$$
$$g_d = g\left(1 - \frac{d}{R}\right)$$

Rearranging these expressions, the relationship between h and d is obtained as $h = d / 2$. Thus, one needs to go twice as deep into the Earth as above its surface to obtain the same value of gravitational acceleration.

1. If the escape velocity of a rocket from the surface of the Earth is v_e , then the escape velocity of the same rocket from the surface of a planet whose acceleration due to gravity as well as radius are 4 times that of the Earth is

- ○ 4 v_e ✓
- ○ 16 v_e
- ◉ v_e / 4 ✗
- ○ v_e

Explanation:

The escape velocity of an object from the surface of a planet of radius R and acceleration due to gravity g is given by

$$v_e = \sqrt{2gR}$$

Increasing both g and R by a factor of 4 will result in the escape velocity increasing by a factor of 4. So, the answer is 4 v_e.

2. A planet is moving around the Sun in a circular orbit of circumference C. The work done on the planet by the gravitational force F of the Sun is

- ○ *FC*
- ○ *FC/2*
- ◉ Zero. ✓
- ○ *F/C*

Explanation:

The work done is given by

$W = F\,S \cos ø$ where F is the force, S is the displacement and ø is the angle between the force and displacement.

Here the angle between the force and the displacement is 90^{o}. Hence the work done is zero.

3. The ratio of the time periods for two satellites of equal mass in circular orbits of radii R and 9 R is

- ◉ 1 : 9 ✗
- ○ 27 : 1
- ○ 1 : 27 ✓
- ○ 9 : 1

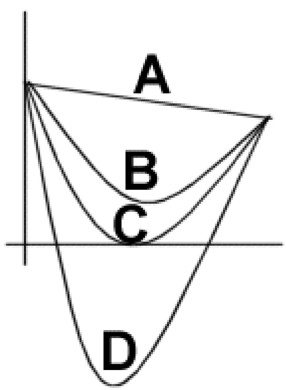
Explanation:
For two satellites of equal mass in circular orbits of radii R_1 and R_2,

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

The above equation is merely Kepler's third law as applied to satellites in circular orbits.
Substituting $R_1 = R$ and $R_2 = R$, the ratio of the time periods turns out to be 1 : .

4. A satellite is moving around the Earth in a circular orbit with a velocity V. If the gravitational force of the Earth were to suddenly disappear, then the satellite would

- move with a velocity V, tangentially to its circular orbit.
- move radially outwards with a velocity V.
- fall towards the surface of the Earth.
- spirally move away from the Earth.



The gravitational acceleration on a planet is 20% less than that on the Earth. A rocket takes a man from the Earth to this planet. On neglecting the effect of all other bodies in the sky, which curve in the figure best describes the change in the man's weight with distance traveled?

- A
- D
- B
- C

When the man is moving from the Earth to the planet, the resultant of the forces acting on him will become zero at one particular point. Hence curve C provides the best description.

. If a simple pendulum with a time period of 2 seconds is made to oscillate at a height R equal to the Earth's radius, then its time period at this height will be

○ 2 s ✗ ○ 1 / 2 s ○ 1 / 4 s ○ 4 s ✓

Explanation:
The acceleration due to gravity at a height *R* above the surface of the Earth is given by

$$g_R = \frac{GM}{(R+R)^2} = \frac{GM}{4R^2} = \frac{g}{4}$$

The time period of the pendulum at this height is

$$T_R = 2\pi\sqrt{\frac{L}{g_R}} = 2\pi\sqrt{\frac{L}{g}} \times \sqrt{4} = 2T$$

Substituting $T = 2$, the time period is found to be 4 s.

5. If the distance between two masses is increased by a factor of 5, the gravitational force of attraction between them will

- ○ reduce by a factor of 25 ✓
- ○ remain Same
- ○ increase by a factor of 5
- ○ reduce by a factor of 5

Explanation:
The gravitational force between two bodies is given by

$$F = \frac{GMm}{R^2}$$

If the distance between the two bodies *R* is increased by a factor of 5, the gravitational force *F* will reduce by a factor of 25.