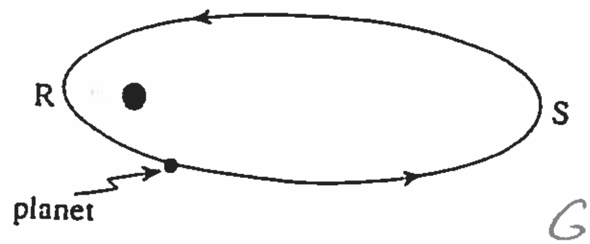
Centripetal Force and Gravitational Potential Energy when not on Earth

Answers

1. A planet is in orbit as shown in the diagram below.



$GPE = \frac{-Gm_1m_2}{\text{"}r\text{"}}$

$r \rightarrow s$ "r" ↑

"r" ↑ so $\left(\frac{Gm_1m_2}{r}\right)$ ↓

but $GPE = -\left(\frac{Gm_1m_2}{r}\right)$

so GPE ↑

The planet's gravitational potential energy will

A. be constant throughout its orbit.
B. always be equal to its kinetic energy.
C. increase as the planet goes from point R to point S.
D. decrease as the planet goes from point R to point S.

2. The gravitational force of attraction between the Sun and an asteroid travelling in an orbit of radius 4.14×10^{11} m is 4.62×10^{17} N. What is the mass of the asteroid?

A. 1.45×10^{9} kg
B. 4.08×10^{9} kg
C. 4.71×10^{16} kg
D. 6.00×10^{20} kg

$F_g = \frac{Gm_1m_2}{r^2} \rightarrow m_2 = \frac{F_g r^2}{Gm_1} = \frac{(4.14 \times 10^{11})^2 (4.62 \times 10^{17})}{[(6.67 \times 10^{-11})(1.98 \times 10^{30})]}$

$m_2 = 5.9958 \times 10^{20}$ kg

3. A child is riding on a merry-go-round which is rotating at a constant rate. Which of the following describes the child's speed, velocity, and magnitude of acceleration?

	SPEED	VELOCITY	MAGNITUDE OF ACCELERATION
A.	constant ✓	constant	constant
B.	constant ✓	changing ✓	constant ✓
C.	changing	constant	changing
D.	changing	changing	changing

4. A satellite is travelling around the Earth in an orbit of radius 4.47×10^{7} m. What is the mass of the satellite if it experiences a gravitational force of 3.00×10^{3} N?

A. 4.37×10^{1} kg
B. 3.06×10^{2} kg
C. 2.14×10^{3} kg
D. 1.50×10^{4} kg

$m_2 = \frac{F_g r^2}{Gm_E}$

$m_2 = \frac{(3.00 \times 10^{3})(4.47 \times 10^{7})^2}{(6.67 \times 10^{-11})(5.98 \times 10^{24})} = 15028$ kg

5. A 1 500 kg spaceship circles a planet once every 4.0×10^{5} s with an orbital radius of 3.6×10^{7} m. What is the mass of this planet?

A. 2.0×10^{11} kg
B. 1.2×10^{12} kg
C. 1.7×10^{23} kg
D. 2.6×10^{26} kg

$m_2 = 1500$ kg
$T = 4.0\times10^{5}$ s
$r = 3.6\times10^{7}$ m
$m_1 = ?$ [kg]

$v = \frac{d}{t} = \frac{2\pi r}{T}$

$F_c = F_g$

$m_2 \frac{v^2}{r} = \frac{G m_1 m_2}{r^2}$

$v^2 = \frac{G m_1}{r}$

$m_1 = \frac{v^2 r}{G}$

$m_1 = \frac{\left(\frac{2\pi r}{T}\right)^2 \cdot r}{G}$

$m_1 = \frac{4\pi^2 r^3}{T^2 G}$

$m_1 \doteq 1.73\times10^{23}$ kg

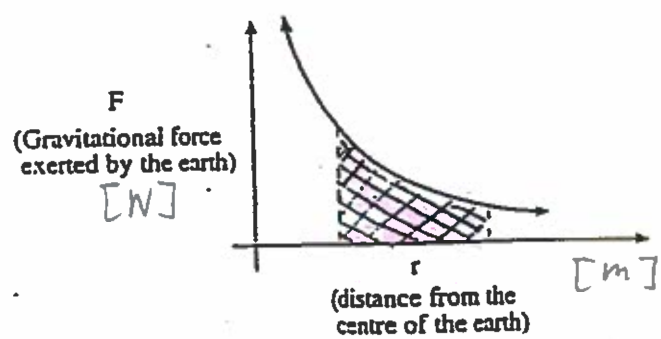
6. An object is located on the surface of a planet. The work required to remove this object from the planet's gravitational field depends on which combination of the following three variables: mass of the planet, mass of the object, and radius of the planet?

	MASS OF PLANET	MASS OF OBJECT	RADIUS OF PLANET
A.	m_1 Yes ✓	m_2 Yes ✓	r_f, r_i Yes ✓
B.	Yes	Yes	No
C.	Yes	No	Yes
D.	No	Yes	Yes

$W = \Delta GPE$
$= GPE_f - GPE_i$
$= -G m_1 m_2 \left(\frac{1}{r_f} + \frac{1}{r_i}\right)$

r_f and $r_i \Rightarrow r_{planet}$ + altitude

7. The shaded area shown in the diagram represents



A. the gravitational field strength near the earth.
B. the escape velocity from the surface of the earth.
C. the centripetal acceleration of an object orbiting the earth.
D. the work required to move an object in the earth's gravitational field.

8. What is the magnitude of the centripetal acceleration of the earth as it orbits the sun?

A. 3.4×10^{-18} m/s²
B. 1.8×10^{-8} m/s²
C. 5.9×10^{-3} m/s²
D. 9.8 m/s²

$r = 1.5\times10^{11}$ m
$T = 3.16\times10^{7}$ s

$a_c = \frac{v^2}{r} = \frac{4\pi^2 r^2}{T^2} \div r \Rightarrow \frac{4\pi^2 r}{T^2}$

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

$a_c = 5.9\times10^{-3}$ m/s²

9. A satellite orbits the earth with a kinetic energy of 2.0×10^{10} J. Its gravitational potential energy in this orbit is -4.0×10^{10} J. What is the total energy of the satellite?

A. -6.0×10^{10} J
B. -2.0×10^{10} J
C. 2.0×10^{10} J
D. 6.0×10^{10} J

$E_{TOT} = KE + GPE$
$= 2.0\times10^{10} + (-4.0\times10^{10})$
$= -2.0\times10^{10}$ J

10. A 450 kg piece of space debris initially at rest falls from an altitude of 6.2×10^{5} m above the earth's surface. What is its kinetic energy just before impact with the surface? (Ignore air resistance.)

$KE = 0$ J

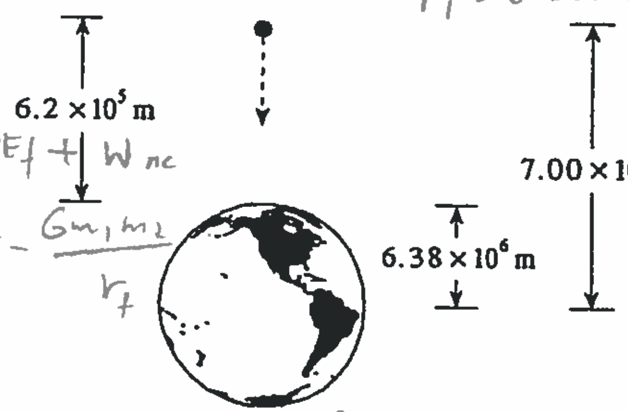
$r_i = 6.38\times10^{6} + 6.2\times10^{5} = 7.0\times10^{6}$ m

$r_f = 6.38\times10^{6}$ m

$E_{TOT\,i} = E_{TOT\,f}$

$KE_i + GPE_i + W_{in} = KE_f + GPE_f + W_{nc}$

$0 - \frac{Gm_1m_2}{r_i} + 0 = \frac{1}{2}m_2v^2 - \frac{Gm_1m_2}{r_f}$



A. 2.5×10^{9} J
B. 2.7×10^{9} J
C. 2.6×10^{10} J
D. 2.9×10^{11} J

$KE = \frac{1}{2}m_2v^2 = -\frac{Gm_1m_2}{r_i} + \frac{Gm_1m_2}{r_f}$

$= \left[(6.67\times10^{-11})(5.98\times10^{24})(450)\right]\left[\frac{1}{r_i} - \frac{1}{r_f}\right]$

$= 2.49\times10^{9}$ J

11. A satellite travels around a planet at 9.0×10^{3} m/s with an orbital radius of 7.4×10^{6} m. What would be the speed of an identical satellite orbitting at one half this radius?

A. 4.5×10^{3} m/s
B. 9.0×10^{3} m/s
C. 1.3×10^{4} m/s
D. 1.8×10^{4} m/s

$v = \sqrt{\frac{Gm}{r}} = \frac{\sqrt{Gm}}{\sqrt{r}} = 9.0\times10^{3}$ m/s

half radius: $v = \frac{\sqrt{Gm}}{\sqrt{\frac{r}{2}}} = \frac{\sqrt{Gm}}{\frac{\sqrt{r}}{\sqrt{2}}} =$

$\frac{\sqrt{Gm}}{1} \times \frac{\sqrt{2}}{\sqrt{r}} = \frac{\sqrt{Gm}}{\sqrt{r}} \cdot \sqrt{2} = (9.0\times10^{3})(\sqrt{2}) = 1.27\times10^{4}$ m/s