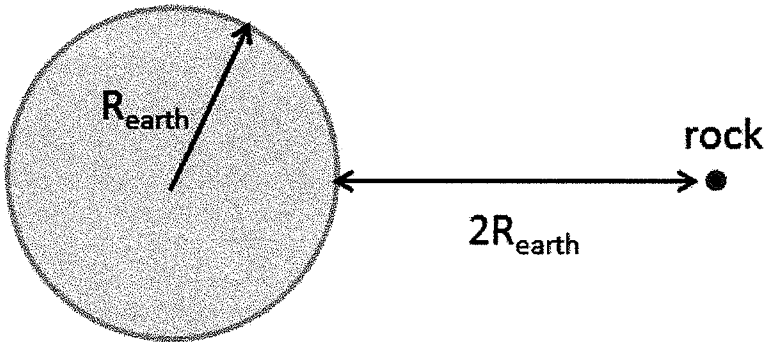
The next two questions pertain to the situation described below.

A rock on the surface of the earth weighs 72 N. The rock is now moved to a position two earth radii from the surface of the earth, as shown in the diagram.



4) What is the gravitational pull of the earth on this rock when it is at the position shown in the diagram?

$F = \frac{GMm}{(3R_e)^2} = \frac{1}{9}\frac{GMm}{R_e^2} = \frac{1}{9}\,72\text{ N} = 8\text{ N}$

We know $\frac{GMm}{R_e^2} = 72\text{ N}$

a. 24 N
b. 72 N
(c) 8 N
d. 18 N
e. 36 N

5) The rock is now released from rest.

Let *m* be the mass of the rock and *M* be the mass of the earth.

Which equation below would be an appropriate application of conservation of mechanical energy, with the initial state shown above, and with the final state being just before the rock strikes the surface of the earth?

$KE + U = KE + U$

$0 - \frac{GMm}{3R_e} = \frac{1}{2}mv^2 - \frac{GMm}{R_e}$

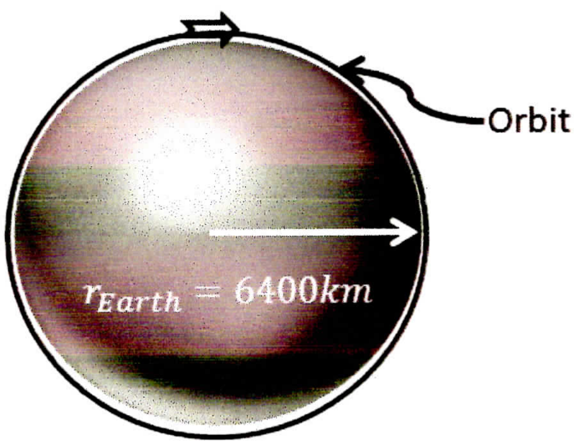
(a.) $-GMm/3R_{earth} = \frac{1}{2}mv^2 - GMm/R_{earth}$

b. $GMm/(2R_{earth})^2 = \frac{1}{2}mv^2$

c. $-GMm/(2R_{earth})^2 = \frac{1}{2}mv^2 - GMm/(R_{earth})^2$

d. $-GMm/2R_{earth} = \frac{1}{2}mv^2 - GMm/R_{earth}$

e. $GMm/3R_{earth} = \frac{1}{2}mv^2 + GMm/R_{earth}$



9) An object is launched with a velocity v such that it begins to orbit around the earth with a radius R. If the object could orbit the Earth just at its surface, how fast would it have to travel? (R_{Earth} =*6400 km*)

a. v = *16 km/s*
b. v = *250 km/s*
c. v = *120 km/s*
(d.) v = *7.9 km/s*
e. $v = 6.3 \times 10^4$ *km/s*

$F = ma = m\frac{v^2}{R}$

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

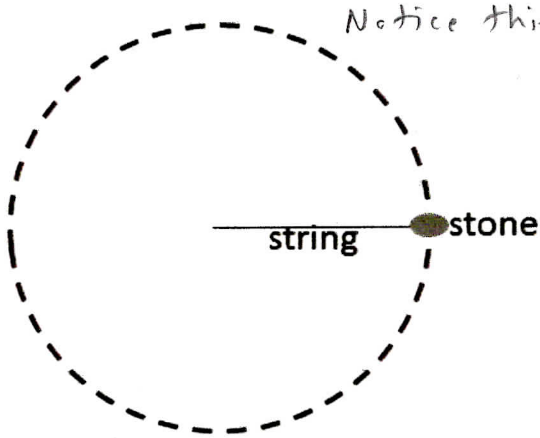
Easier way: Notice this is g:

$\Rightarrow v = \sqrt{\frac{GM}{R}}$

$= \sqrt{\frac{6.673 \times 10^{-11} m^3 kg^{-1} s^{-2} \times 6 \times 10^{24} kg}{6400 \times 10^3 m}}$

$= 7900$ m/s

$= 7.9$ km/s



$g = \frac{v^2}{R} \Rightarrow v = \sqrt{gR}$

$= \sqrt{9.8 \, m/s^2 \times 6400 \times 10^3 m}$

$= 7900$ m/s $= 7.9$ km/s

10) A boy uses a string to swing a *2.2 kg* stone around his head. The string is *1.5 m* long, and can bear a maximum tension of *1012 N*. What is the maximum speed at which the boy can swing the stone without breaking the string?

a. v = *394 m/s*
b. v = *690 m/s*
c. v = *26.3 m/s*

The next two questions relate to the following situation:

The orbital period of the Moon is T = 27 days, and its distance from the Earth is R = 384,000 km. Assume that the mass of the Earth is much, much greater than that of the Moon; the Earth will therefore be at the center of the Moon's circular orbit.

$v = \omega R \qquad \omega = \frac{2\pi}{T} = \frac{2\pi}{27\ \text{days}} \times \frac{\text{day}}{24\ \text{hr}} \times \frac{\text{hr}}{3600\ \text{s}}$

24. What is the Moon's linear speed?

$= 2.7 \times 10^{-6}\ s^{-1}$

A) 160 m/s
(B) 1,000 m/s
C) 14 x 10^6 m/s

$v = 2.7 \times 10^{-6}\ s^{-1} \times 384{,}000 \times 10^3\ m$

$= 1034\ m/s$

25. Using this information, what is the mass of the Earth? G = 6.673 x 10^{-11} $m^3\ kg^{-1}\ s^{-2}$

A) 6.0 x 10^{21} kg
B) 1.5 x 10^{23} kg
(C) 6.2 x 10^{24} kg
D) 8.1 x 10^{25} kg
E) 1.1 x 10^{33} kg

$F = ma = m\frac{v^2}{R} \Rightarrow M = \frac{v^2 R}{G}$

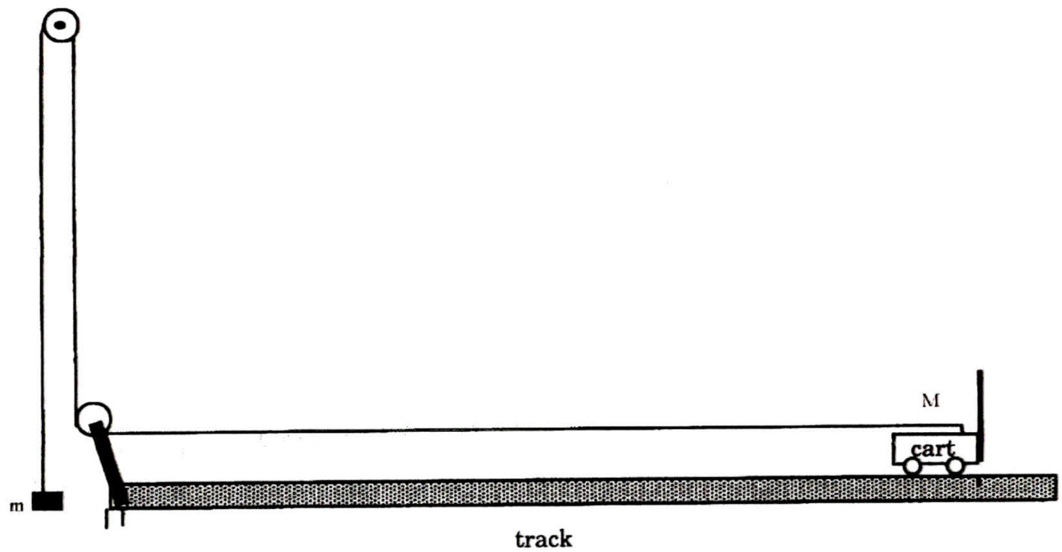
$F = \frac{GMm}{R^2}$

$= \frac{(1034\ m/s)^2 \times 384 \times 10^6\ m}{6.673 \times 10^{-11}\ m^3\ kg^{-1}\ s^{-2}}$

$= 6.15 \times 10^{24}\ kg$

Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?

18. The following question refers to the drawing below, which is similar to that used in the labs. The cart with mass M = 3 kg is pulled by a massless string and moving on a horizontal track. A weight with mass m = 1kg is hung from the other end of the string through a pulley system. Ignore all friction forces ($g = 9.8\ m/s^2$). Due to the gravitational force acting on weight of mass m, the cart is accelerated to the left.



What is the tension (T) in the string?

a. T = 3.27 N
b. T = 4.9 N
c. T = 7.35 N
d. T = 9.8 N
e. T = 29.4 N

---

19. In another galaxy, a solar system similar to our own contains a planet that has the same mass as Earth, but it is made of a less dense rock, so its radius is 1.3 times the Earth's radius. How much would a 80 kg person weigh on the surface of that planet? The mass of Earth is 5.9742×10^{24}kg and the radius of Earth is 6.378×10^3 km.

a. 175 N
(b) 464 N
c. 603 N
d. 784 N
e. 1019 N

$$W = F = \frac{GMm}{R^2} = \frac{GM_E}{(1.3 R_E)^2} \cdot m = \frac{GM_E}{R_E^2} \times \frac{m}{(1.3)^2}$$

$$= g \frac{m}{(1.3)^2}$$

$$= 9.8\ m/s^2 \times \frac{80\ kg}{(1.3)^2}$$

$$= 464\ N$$

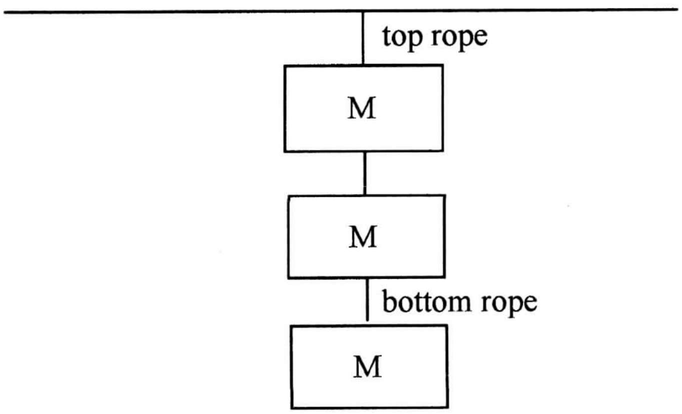
10. An astronaut free falls toward the Earth at a distance of 3 Earth radii from the center of the Earth. What is his acceleration?

$F = ma$, $\frac{GMm}{(3R)^2}$ $\Rightarrow$ $a = \frac{GM}{9R^2} = \frac{1}{9} g = \frac{1}{9} 9.8 \ m/s^2 = 1.1 \ m/s^2$

a. 0.01 m/s^2
b. 0.11 m/s^2
(c.) 1.1 m/s^2
d. 9.8 m/s^2
e. It is impossible to tell from the information given.

The following 2 questions concern the same physical situation:

Three weights of mass M are hung from the ceiling using three ropes. The top on is hung directly from the ceiling, the second is hung below the first one, and the third one is hung below the second one (see diagram).



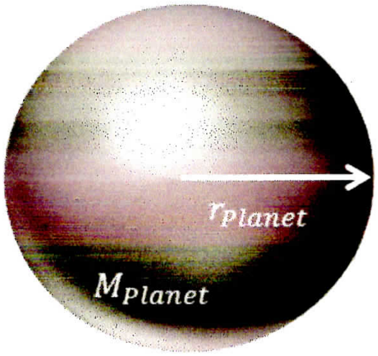
11. Which of the following is true?

a. the tension in the top rope is the same as that in the bottom rope.
b. the tension in the top rope is less than that in the bottom rope.
c. the tension in the top rope is more than that in the bottom rope.

12. Suppose that the mass of the lowest weight was doubled. By what factor would the tension in the top rope increase?

a. 1.33
b. 1.5
c. 2

The next three questions pertain to the situation described below.



The *weight, W,* of an object on a planet can be calculated using: $W = G\,M_{planet}m/r^2_{planet}$. You travel from Earth to a new planet where M_{planet} is the mass of the planet and r_{planet} is its radius.

4) Which of the following do you need to know to calculate your *weight* on the new planet?

$$W = \frac{G\,M_{planet}\,m}{r^2_{planet}}$$

a. M_{planet} only.
b. r_{planet} only.
c. M_{planet} and r_{planet}.

5) If the mass of the new planet is $3.2M_{Earth}$, but the radius is $r_{planet} = r_{Earth}$, how does your *weight* change compared to on Earth?

a. It gets smaller by 3.2 times.
b. It gets larger by 3.2 times.
c. It stays the same.

6) If the radius of the new planet is $7.7r_{Earth}$, but the mass is $M_{planet} = M_{Earth}$, how does your *weight* change compared to on Earth?

a. It stays the same.
b. It gets smaller by 7.7 times.
c. It gets smaller by 7.7^2 times.
d. It gets larger by 7.7 times.
e. It gets larger by 7.7^2 times.