Physics 200
23-24 Practice Test: Circles and Gravity

Name: Key

7

a. What does "uniform circular motion" mean?

Motion in a circular path at a constant speed

b. When an object is in uniform circular motion, is it accelerating? Provide evidence to support your answer.

Yes. It's direction is changing. Velocity is speed and direction. Acceleration is changing velocity.

c. Theoretically, any object in the Universe can be made to move in uniform circular motion. For any object, what would you need to do to in order to make this happen?

First, make sure it's moving → Then Apply force(s) to the object so that it's net force is always constant, and perpendicular to it's velocity, and in the same plane.

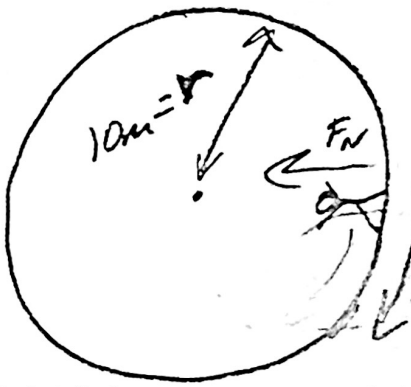
8

How do we sense gravity?

We feel normal forces (F_N) -- the ground against our feet; our guts against our abdominal cavity; fluid against our inner ears.

3.

Create some plans to produce a 0.4g_{Earth} "artificial gravity" environment for explorers who are traveling to Mars. The goal is to create a sensation of weight similar to what the astronauts will experience on Mars – 0.4 times their weight on Earth. Do the math and draw a diagram complete with numbers, measurements, units, and indications of motion. Draw at least one astronaut. The diagram should convey enough information so that a reader can confirm that the astronauts will feel like they are in a 0.4g_{Earth} environment. There are an infinite number of possible solutions.



$F_N = m(0.4g) = m(3.92\ m/s^2)$

$\Sigma F = m(3.92\ m/s^2) = \frac{mv^2}{r}$

Let r = 10 m ⇒ $3.92\ m/s^2 = \frac{v^2}{10\ m}$

$v = 6.3\ m/s$

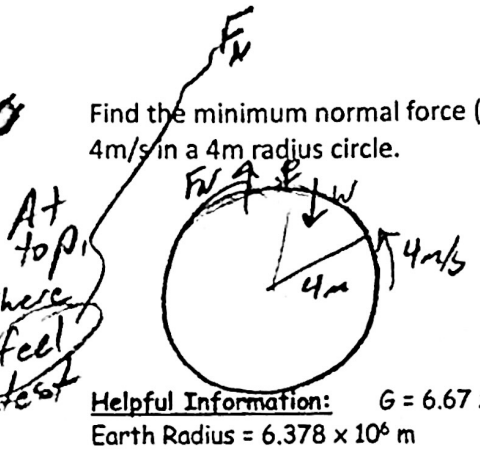
4.

Explain briefly how your structure mimics a 0.4g environment.

On Earth, $F_N = mg = m(9.8\ m/s^2)$

On this structure, $F_N = m(0.4\ g_{Earth}) = m(3.92\ m/s^2)$

2. Find the minimum normal force (F_N) felt by a 70kg human riding a Ferris Wheel if the human is moving at 4m/s in a 4m radius circle.



$$\Sigma F = -\frac{mv^2}{r} = F_N - mg \Rightarrow F_N = mg - \frac{mv^2}{r}$$

$$F_N = m\left(g - \frac{v^2}{r}\right)$$

$$F_N = 70\text{kg}\left(9.8\text{m/s}^2 - \frac{(4\text{m/s})^2}{4\text{m}}\right) \Rightarrow 406\text{N}$$

Helpful Information: $G = 6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2$ $M_{Earth} = 5.97 \times 10^{24}$ kg $M_{Moon} = 7.35 \times 10^{22}$ kg

Earth Radius = 6.378×10^6 m Earth Orbital Radius = 1.50×10^{11} m

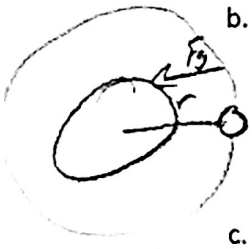
Moon Radius = 1.74×10^6m

6. a. The Moon exerts a gravitational force on the Earth that is roughly 2×10^{20} N. What is the Moon's orbital radius?

$$F_g = G\frac{M_m}{r^2} \quad 2\times10^{20}\text{N} = 6.67\times10^{-11}\frac{\text{Nm}^2}{\text{kg}^2}\left(\frac{(7.3\times10^{22}\text{kg})(5.97\times10^{24}\text{kg})}{r^2}\right)$$

$$r = 3.81\times10^8\text{m}$$

b. What is the Moon's orbital velocity?



$$\Sigma F = F_g = \frac{mv^2}{r} \Rightarrow 2\times10^{20}\text{N} = \frac{7.3\times10^{22}\text{kg}(v^2)}{3.81\times10^8\text{m}} \Rightarrow v = 1{,}022\ \text{m/s}$$

c. What is the Moon's orbital period, in seconds?

$$d = rt \quad 2\pi r = vT \Rightarrow T = \frac{2\pi r}{v} = \frac{2\pi(3.81\times10^8\text{m})}{1{,}022\text{m/s}} = 2.34\times10^6\text{s}$$

5. What is the value of g on the Moon, in m/s^2?

$$mg = G\frac{M_m}{r^2} = 6.67\times10^{-11}\frac{\text{Nm}^2}{\text{kg}^2}\left(\frac{7.35\times10^{22}\text{kg}}{(1.74\times10^6\text{m})^2}\right) = 1.62\text{m/s}^2$$

10. A 65kg student (weight = 637N) is running on an indoor "track" in a school gym. The student needs to make a circular turn with a radius of 15m, but the maximum force of friction between the student's shoes and the floor is 450N. What is the maximum speed at which the can the student make the turn without slipping?

$$\Sigma F = F_{fr} = \frac{mv^2}{r}$$

$$450\text{N} = \frac{65\text{kg}(v^2)}{15\text{m}} \Rightarrow v = 10.2\text{m/s}$$