

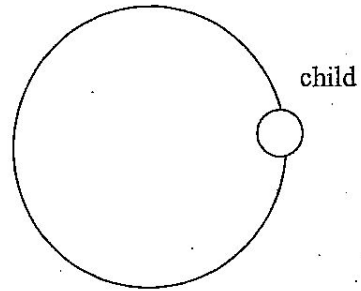
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PHY 111

Circular Motion Problems

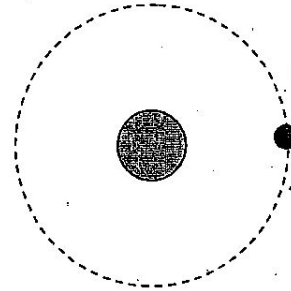
1. A 30-kg child is sitting on the edge of a spinning merry-go-round. The merry-go-round has a radius of 2 m and it takes 5 seconds for the merry-go-round to make one revolution.

- What is the velocity of the child in meters/sec?
- With how much force does the child have to hold on? What is the direction of the force on the child?



2. A 100-kg satellite has been put into orbit around a planet. The radius of the orbit is 8000 km (1 km = 1000 m). If the velocity of satellite 4600 m/sec, what is the force of gravity on the satellite? Draw a force diagram for the forces on the satellite.

(You *don't* need to use the expression $F_{grav} = G \frac{m_1 m_2}{r^2}$.)



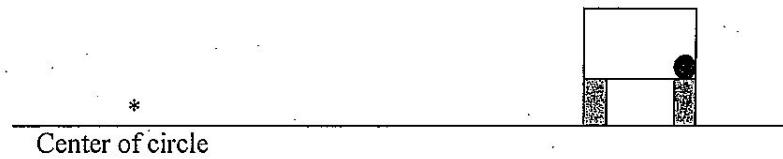
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PHY 111

Circular Motion Problems

1. A 6-kg bowling ball is on the floor of a car which is going around a turn. The speed of the car is 30 m/s and the radius of the turn is 80 m.

- a) What kind of force is the centripetal force acting on the bowling ball?
(Choices: tension, friction, normal, gravity)
- b) Draw a force diagram on the bowling ball?
- c) What is the numerical value of the centripetal force on the bowling ball?

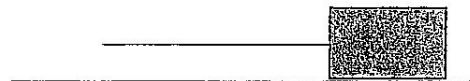


2. A 200-g block on a 50-cm string swings in a circle on a horizontal, frictionless table at 40 rpm (revolutions per minute).

- a) What is the period of the motion?
Note: Period is measured in seconds/revolution.
You are given 40 rev/minute or 40 rev/60 sec.

b) What is the speed of the block?

- c) Draw a force diagram on the block.
What kind of force is the centripetal force?
(Choices: tension, friction, normal, gravity)



d) What is the tension in the string?

3. The coefficient of static friction for a certain kind of pavement and tires is $\mu_s = .9$ when the pavement is dry, $\mu_s = .6$ when the pavement is wet, and $\mu_s = .3$ when the pavement is icy.

a) How fast can a 1000-kg car take a 40-m radius turn when the pavement is dry? Convert to mph.

b) How fast can a 2000-kg car take a 40-m radius turn when the pavement is dry? (Does the mass of the car affect the maximum speed?)

c) How fast can the car take a 40-m radius turn when the pavement is wet? Convert to mph.

d) How fast can the car take a 40-m radius turn when the pavement is icy? Convert to mph.

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PHY 111 Centripetal force/Car making turn

Suppose the coefficient of static friction between the tires of a 1000-kg car and the road is .9.

a) How fast can the car take a turn whose radius of curvature is 40 m?

b) How fast can the car take a turn whose radius of curvature is 30 m?

c) Suppose the car is traveling at a speed of 25 m/s. We will want to find out what is the minimum radius of curvature needed in order for the car to safely make the turn.

Before we actually make the calculation, try to predict into what range the answer will fall.

- i) less than 30 m.
- ii) between 30m and 40 m.
- iii) more than 40 m.

Explain your reasoning.

Now find the minimum radius of curvature needed in order for the car to safely make the turn.

PHY 111

Force of gravity problems

There is a force of gravity between every two objects. The more massive the objects, the more the force. The greater the distance between them, the less the force. The force of gravity is given

by the equation $F_{grav} = G \frac{m_1 m_2}{r^2}$.

1. Two people with a mass of 60 kg each are sitting 1 meter apart in a class room. What is the gravitation attractive force between them? Before you calculate, do you expect the force to be large or small?

2. The Earth has a mass of 5.975×10^{24} kg and a radius of 6.37×10^6 m. A 1000-kg satellite is 800 km above the surface of the Earth.

a) How far is the satellite from the center of the Earth? (Be sure to write all distances in meters.)

b) What is the force of gravity between the Earth and the satellite? (Compare this to the force of gravity at the surface of the Earth which is about 10,000 N [more exactly 9800 N if we use $g = 9.8$].)

3. What is the force of gravity between the Sun and the former plate Pluto? The mean distance between the Sun and Pluto is 5.874×10^{12} m.

$m_{Sun} = 1.99 \times 10^{30}$ kg

$m_{Pluto} = 1.31 \times 10^{22}$ kg

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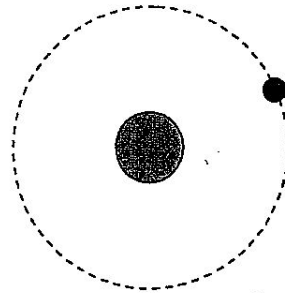
PHY 111

Spacecraft in orbit

$$F_{\text{centripetal}} = \frac{mv^2}{r}$$

$$F_{\text{grav}} = G \frac{m_1 m_2}{r^2}$$

a) What is the force of gravity between a 500-kg satellite and a planet whose mass is 2×10^{24} kg. The radius of the orbit (which is the same as the distance of separation) is 7×10^6 m.

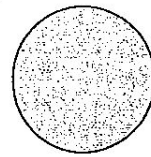


b) The force of gravity you found in part (a) is just the centripetal force. Use $F_{\text{cent}} = \frac{mv^2}{r}$ to find the velocity of the satellite as it orbits the planet.

c) What is the period of the satellite orbit around the planet?

2. Suppose a 2000-kg spacecraft is in orbit around the Earth at a distance of 20,000 km from the center of the Earth. The mass of the Earth is 5.975×10^{24} kg.

- a) Draw a force diagram on the spacecraft.
- b) What is the net force on the spacecraft?
- c) What is the velocity of the spacecraft?
- d) What is the circumference of the orbit?
- e) What is the time required for the spacecraft to make one complete orbit around the Earth (give the time in days or hours).



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PHY 111 Moon in orbit: Ganymede

There are several moons orbiting Jupiter.

The moon Ganymede has a mass of 1.4819×10^{23} kg. The radius of its orbit around Jupiter is 1,070,000 km.

The mass of Jupiter is 1.90×10^{27} kg

a) What is the force of gravity between Jupiter and Ganymede?

b) What is the velocity of Ganymede as it orbits Jupiter?

c) What is the period of Ganymede's orbit around Jupiter?

d) The radius of Ganymede is 2634 km. What is the acceleration of gravity (g) on the surface of Ganymede? (This question is unrelated to the orbit of Ganymede around Jupiter.)

PHY 111 Acceleration of gravity on Pluto

The former planet Pluto has a mass of 1.3×10^{22} (1.3E22) kg and a radius of 1195 km.

a) What is the acceleration of gravity on Pluto?

b) Objects on Pluto weigh what fraction of the weight they would have on Earth?

c) A fellow astronaut, who with his space suit weighs 250 lbs on Earth, has fallen unconscious while exploring the surface of Pluto. How hard would it be to pick up this astronaut and carry him back to the space ship?

Why is Pluto no longer a planet?

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PHY 111 Rocket Science: Velocity and period of Apollo 11 in lunar orbit

While two of the Apollo 11 astronauts descended to the lunar surface in the lunar module, the third astronaut orbited the moon in the command module (5000 kg) at an altitude of about 60.6 nautical miles. (1 nautical mile = 1853 meters.) For about half of his orbit, the astronaut in the command module was out of contact with the Earth as well as out of contact with the astronauts on the surface.

a) Determine the **orbital speed** and **orbital period** of the command module.

b) About how long was the communication blackout?

mass of moon = 7.36×10^{22} kg

radius of moon = 1.74×10^6 m

c) While the astronauts were in orbit around the moon, they seemed to be weightless in the command module. What would be the actual force of gravity on a 70-kg astronaut in orbit around the moon?

PHY 111

Centrifuge

A technician at a medical lab puts a 5 gram sample of blood into a centrifuge. The centrifuge spins at a rate of 10,000 rpm. The radius of the spin is 15 cm.

a) If the rate of spin is 10,000 revolutions per minute, what is the time (in seconds) of one period?

b) What is the velocity of the blood sample as it spins?

c) What is the force on the blood sample as it spins?

This force is how many times greater than the usual weight of the 5 gram sample?

d) What is the acceleration of the sample?

e) What is the acceleration in terms of g's?

