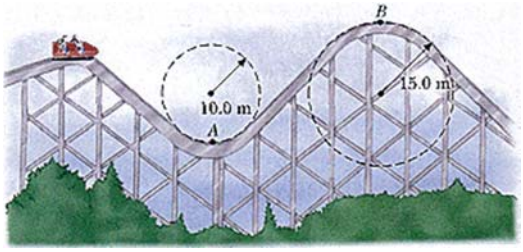
Name_____

Worksheet #2

Circular Motion and Universal Gravitation

1. A roller-coaster car has a mass of 498 kg when fully loaded with passengers.



(a) If the car has a speed of 20.2 m/s at point *A*, what is the force exerted by the track on the car at this point?

25,200 N

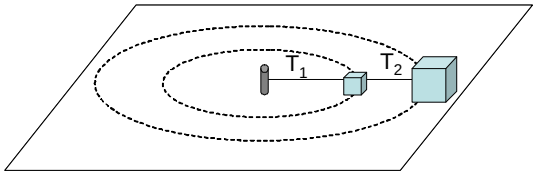
(b) What is the maximum speed the car can have at *B* and still remain on the track?

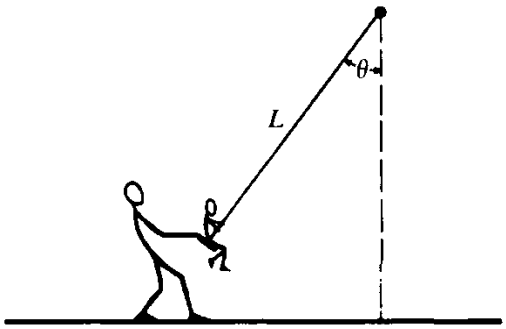
12.1 m/s

2. Two masses, 30 g and 50 g, are attached in line via two strings and spun around in uniform circular motion on a frictionless horizontal surface, as shown below. The radius of the 30 g mass's motion is 0.5 m and the radius of the 50 g mass's motion is 0.75 m. Determine the tension in the inner string (T_1) and in the outer string (T_2) when the masses are spun around 5 times every 10 seconds.

T_1 0.52 N

T_2 0.37 N





*Actual AP Problem

3. An adult exerts a horizontal force on a swing that is suspended by a rope of length L, holding it at an angle θ with the vertical. The child in the swing has a weight W and dimensions that are negligible compared to L. The weights of the rope and of the seat are negligible. In terms of W and θ, determine

a. the tension in the rope;

b. the horizontal force exerted by the adult.

c. the tension in the rope just after the release (the swing is instantaneously at rest);

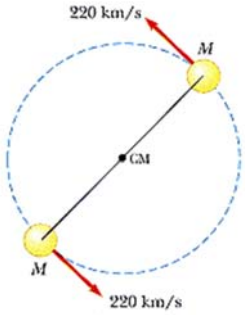
d. the tension in the rope as the swing passes through its lowest point.

4. You are explaining to friends why astronauts feel weightless orbiting in the space shuttle, and they respond that they thought gravity was just a lot weaker up there. Convince them and yourself that it isn't so by calculating how much weaker gravity is at h = 220 km above the Earth's surface.

0.935 (g_h / $g_{surface}$)

5. Plaskett's binary system consists of two stars that revolve in a circular orbit about a center of mass midway between them. This means that the masses of the two stars are equal. If the orbital velocity of each star is 220 km/s and the orbital period of each is 23.9 days, find the mass M of each star. (For comparison, the mass of our Sun is 1.99 ×10^{30} kg.)

105 solar masses



*Actual AP Problem ***(No Answers Given)***

6. An explorer plans a mission to place a satellite into a circular orbit around the planet Jupiter, which has mass M_J = 1.90 x 10^{27} kg and radius R_J = 7.14 x 10^7 m.

a. If the radius of the planned orbit is R, use Newton's laws to show each of the following:

The orbital speed of the planned satellite is given by $v = \sqrt{\frac{GM_J}{R}}$	
The period of the orbit is given by $T = \sqrt{\frac{4\pi^2 R^3}{GM_J}}$	

b. The explorer wants the satellite's orbit to be synchronized with Jupiter's rotation. This requires an equatorial orbit whose period equals Jupiter's rotation period of 9 hr 51 min = 3.55 x 10^4 s. Determine the required orbital radius in meters.
