Dynamics

5.1 Centripetal Force

- Intro.
- Definition

Conceptual Question 1 A penny on a rotating turntable. Where on the platter does the penny require the largest net force to remain in place?

- Demo

- Example 1: Don’t know or care what interactions provide the net force. A 350-kg bobsled going 34 m/s executes two turns (a) one with a radius of curvature of 33 m and (b) one with a radius of curvature of 24 m. What must be the net force on the bobsled in these two cases?

- Example 2: Know and care what interactions provide net force. During the winter time in Minnesota, places like Home Depot do good business in selling bags of sand. 1) It is spread on unshoveled walks and unplowed drives to increase the coefficient of friction -> static friction. 2) It is carried in vehicles to increase their mass -> normal force -> static friction. When it comes to taking an unbanked curve, does the latter really help? Find the maximum speed you can take an unbanked curve as a function of your mass.

- Conceptual Question 2 Is it easier to take an unbanked curve on the Moon or on the Earth?

- Ex. 3 Know and care what interactions provide net force. Man rides on a “swing” ride at a carnival. The man rides in a swing at the end of a 12.0 m chain which hangs out at 65° up from vertical. Assuming uniform circular motion, and a combined, chair+man, mass of 220 kg, (a) what is the tension in the chain? (b) what is tangential speed of the chair?

- Conceptual Question 3 Why must a real airplane bank to turn while a model airplane needn’t (though ours in lab do)?

5.2 Banked Curves

- Swing Chair
- Air Plane
- Car

  - Example 4: A) If you’re taking the interchange between I-10 West and I-125 (?) South, you may well be going 65 mph around a curve with a radius of curvature of 1/8 mi. If it was designed for this speed, at what
angle should it be banked? B) If your tires have a coefficient of static friction of 0.9, How fast could you take that same curve without sliding?

5.4 Satellites in Circular Orbits

- **Intro. Gravitational Central force**
  - **Example 5 (Like HW 30) Moon Speed:** If the moon is $3.85 \times 10^8$ m from the center of the Earth and the Earth has a mass of $5.98 \times 10^{24}$ kg, how fast must it be moving?
  
  - **Ex.6 Moon distance:** Or, based only on knowing the mass of the Earth ($5.98 \times 10^{24}$ kg) and the period of the moon’s orbit (1 sidereal month = 27.3 days = $2.36 \times 10^6$ s) we could find how far the moon is from the (center of the) Earth – it’s radius of orbit.
  
  - **Ex.7 Geo-synchronous satellites.** (same math) It’s awfully useful having a satellite hanging in a stationary position in the sky, i.e., orbiting with the same period as the Earth spins. But if there is a unique speed – radius relationship, then all the geo-synchronous satellites are out at the same radius – what is that radius?

- **Other gravitational orbits**
  - **Ex. 8 Earth about the Sun.** Astronomers can easily tell you how far we are from the sun, about $1.50 \times 10^{11}$ m, and you are quite familiar with the period of our orbit, a year (365.25 days). Using these two piece of information, we can ‘measure’ the mass of the sun!

- **Apparent “Weightlessness” and “Artificial Gravity”**
  - **Apparent Weightlessness**
  - **Artificial Gravity**
    - **Example 9 Space Station Spinning in outer space.** Say you had a 1 km radius space-station, with what period must it spin to provide a normal force equal to that on Earth?

### Problems from Cutnell & Johnson 6th Ed., solutions from accompanying source.

14. At an amusement park there is a ride in which cylindrically shaped chambers spin around a central axis. People sit in seats facing the axis, their backs against the outer wall. At one instant the router wall moves at a speed of 3.2 m/s, and an 83-kg person feels a 560-N force pressing against his back. What is the radius of a chamber?

20. At what angle should a curve of radius 150 m be banked, so cars can travel safely at 25 m/s without relying on friction?

30. The moon orbits the earth at a distance of $3.85 \times 10^8$ m. Assume that this distance is between the centers of the earth and the moon and that the mass of the earth is $5.98 \times 10^{24}$ kg. Find the period for the moon’s motion around the earth. Express the answer in days and compare it to the length of a month.