Module #7: Uniform Circular Motion and Gravity

* Uniform Circular Motion
  + Uniform circular motion – motion in a fixed circle at a constant speed
  + The sum of the torques is zero, not experiencing rotational acceleration
  + All objects that exhibit uniform circular motion have a non-zero acceleration
    - Even though the speed does not change, the direction does
  + Figure 7.1
    - When an object is in uniform circular motion, the velocity vector is always tangent to the circle in which the object is traveling
    - The acceleration is always directed into the circle, along the radius
    - Newton’s Second Law tells us that the force vector is always pointed in the same direction as the acceleration
  + Even though there is a net force acting on the object there is no net torque
    - There is no force perpendicular to the lever arm
* Centripetal Force and Centripetal Acceleration
  + Centripetal force – the force necessary to make an object move in a circle. It is directed towards the center of the circle.
  + Centripetal acceleration – the acceleration cause by centripetal force.
  + Centripetal force is necessary for any kind of circular motion.
  + Experiment 7.1: Centripetal Force (50 min)
  + FC = (mv2) / r
    - FC = centripetal force
    - M = mass of the object that is moving
    - V = speed of the object
    - R = radius of the circle
    - Units = Newtons
  + ac = v2 / r
    - ac = centripetal acceleration
    - v = speed
    - r = radius
  + Ex 7.1 p.222
  + OYO #7.1-7.2 p.223
* The Source of Centripetal Force
  + Example #1: a boy is twirling a toy airplane on a string at a constant rate. What causes the centripetal force?
    - The tension in the string
  + Example #2: riding your bike in a circle. What causes the centripetal force?
    - Friction acting on the tires
  + Ex. 7.2 p.225-227
  + On a flat curve, the mass of the car does not affect the speed at which it can stay on the curve.
    - A larger mass will have greater frictional force, but also requires a greater centripetal force
  + OYO #7.3-7.4 p.228
* A Fictional Force
  + Centrifugal force is not the same as centripetal force even though they are both associated with circular motion.
    - Centrifugal force is actually not a real force
* Gravity
  + Gravity = the attractive force that exists between all objects which have mass
    - All objects which have mass are attracted to all other objects which have mass
  + There are two theories as to why this occurs
    - One theory states that all objects exchange tiny particles called gravitons. All masses like to exchange these particles and they try to get as close as possible to each other in order to facilitate such exchange.
      * Similar to how the exchange of photons is what causes the force between charges and magnets
    - The other theory was proposed by Albert Einstein and is called the General Theory of Relativity. States that mass deforms space and time in its vicinity. This deformity tends to make a “hole” in space and time, and any masses near the hole will fall down the hole, towards the mass that caused the deformation.
      * Best explanation of gravity
  + Sir Isaac Newton developed an equation called the Law of Universal Gravitation:
    - Fg = (Gm1m2) / r2
      * Fg = force due to gravity
      * G = universal gravitational constant
        + Value never changes = 6.67 x 10-11 Nm2 / kg2
      * m1 m2 = masses of the objects
      * r = distance between the centers of the two objects
      * Applies to every object in the universe
    - If “r” is large the gravitational attraction is weak. The closer they are, the stronger the attraction.
  + Example 7.3 p.231
    - The more massive things are, the more powerful gravity becomes
    - For most objects in day-to-day life, the gravitational force that exists between them is far weaker than the static frictional force holding the objects stationary.
  + Example 7.4 p.233
  + The value we have learned for the acceleration due to gravity is just an approximation
    - Actually depends on the distance between the objects
    - The radius of the earth is large enough to overwhelm the effect of the object’s position relative to the surface of the earth
  + OYO #7.5 p.234
* Circular Motion Terminology
  + Period (T) = the time it takes for an object in uniform circular motion to travel through one full circle
  + Frequency (f) = the number of times per second an object in uniform circular motion travels around the circle
    - The unit for frequency is 1/sec which is often abbreviated “Hz” for Hertz
  + If the period is large, the frequency will be small. If the period is small the frequency will be large.
    - Period and frequency are inversely related
    - f = 1/T
  + Ex 7.5 p.236
  + OYO #7.6 p.236
* Gravity and the Motion of Planets
  + The sun exerts a gravitational force on each of the planets, pulling each planet towards the center of the sun.
  + The sun’s gravitational attraction supplies a centripetal force to each planet, causing it to move in a circle
    - While they are actually ellipses, in this course we will treat them as circles
  + Ex 7.6 p.238
  + Ex 7.7 p.239
  + We measure mass by doing gravitational calculations that utilize our gravity and centripetal force equations.
  + Read p.241-242 (extra info about satellites and Milky Way)
  + OYO #7.7-7.10 p.242