Module #6 Applications of Newton’s Second Law

Translational Equilibrium

* Newton’s Second Law states that the sum of the forces on an object is equal to the mass of that object times its acceleration.
* What happens if the sum of the forces on an object is zero?
  + Ex. Two equal forces in opposite directions
* Transitional equilibrium – an object is said to be in translational equilibrium when the sum of the forces acting on it is equal to zero.
  + The object has no acceleration
  + Can either be at rest or moving at a constant velocity
  + When an object is at rest, it is said to be in static equilibrium (focus on this, this chapter)
  + When an object moves with a constant velocity, it is said to be in dynamic equilibrium
* Ex: Hanging Lamp (p.178) diagram
  + The force of gravity is equal to m\*g down
  + The rope is fighting gravity using tension
  + Tension = the force from a tight string, rope, or chain. This force is directed away from the object to which the string, rope, or chain is anchored.
  + Sum of forces = zero
  + T=mg
* Example 6.1 p.179-181
  + A 50.0 Newton painting is hung from a ceiling with two strings at 45 degree angles. What is the tension in each string?
* Solving a problem
  + First, identify all of the forces in the problem
  + Split the two-dimensional force vectors into their components and add the components in each dimension separately
* Example 6.2 p.182-184
  + A 5.00 kg flower pot is suspended from two strings as shown below. What is the tension in each string?
  + Solving for two variables with two equations
* OYO p.184-185
  + #6.1-6.3

Translational Equilibrium and Measuring Weight

* There are situations in which a scale will not give you an accurate reading for your weight
* Measuring Weight on an Elevator (fig 6.1)
  + A scale reads normal force
  + Gravity pulls you down (w) while the scale pushes you up with a normal force (Fn).
    - Fn – w = ma
    - Fn = ma + w
  + When the elevator is still the acceleration is zero, so Fn = w
  + Once the elevator begins to accelerate, the normal force is the sum of your weight plus your mass time acceleration
  + Since weight is defined as negative, if the elevator accelerates downward, a must be negative
* OYO p.188 #6.4

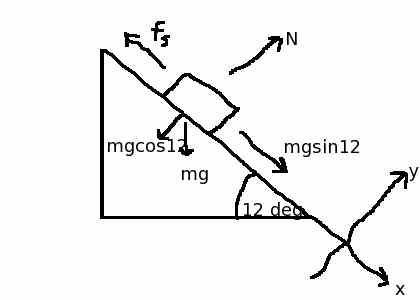
Rotational Motion and Torque

* Translational motion = motion from one point to another which does not involve repeatedly passing the same point in space
  + Moves from one point to another
  + The magnitude of the force applied to an object determines the amount of translational acceleration that will occur.
* Rotational motion = motion around a central axis such that an object could repeatedly pass the same point in space relative to that axis
  + Axis of rotation = the point in space that s the center of rotational motion
    - If an object is moving in a circle, the center of the circle is the axis of rotation
  + To cause rotational acceleration a force must be direction perpendicular to an imaginary line from the axis of rotation to the point of the applied force
    - This imaginary line is called the lever arm
    - Rotational acceleration is easier to induce the farther the applied force is away from the axis of rotation
* Torque = the tendency of a force to cause rotational acceleration. The magnitude of the torque is equal to the length of the lever arm times the component of the force that is applied perpendicular to it
  + τ = F┴ \* r
    - τ represents Greek letter “tau”, symbol for torque
    - F┴ represents the component of the applied force that is perpendicular to the lever arm
    - r stands for the length of the lever arm
  + The amount of torque applied to an object determines the amount of rotational acceleration that will occur.
* Example 6.3 p.192
  + A plumber is trying to unscrew one pipe from another with a 6.00 in (15.2 cm) wrench. He pulls down on the wrench with all of his might (a force of 653 Newtons), but cannot unscrew the pipe. He pulls a 12.0 in (30.5 cm) wrench out and tries again, using the same force. This time the pipe unscrews quote readily. Examine the two torques applied in order to see why. In each case, assume that the plumber grasps the wrench at the very end and that the applied force is perpendicular to the lever arm. Also, the length of a wrench is given from the axis of rotation of the object in its grasp, so the length of each wrench is the length of the lever arm.
* OYO p.193 #6.5
* If the force applied is not perpendicular, you must break it down into its components and find out what part of the force is directed perpendicular to the lever arm. Only that component of force counts towards the torque
  + For all problems in this course, we will always assume that the applied force is perpendicular to the lever arm.

Rotational Equilibrium

* A rod placed unequally on a fulcrum cannot stay balanced because it is not in rotational equilibrium.
* The sum of the forces acting on the rod equals zero, but the sum of the torques does not.
* If the fulcrum is not placed at the center of the rod, gravity has a longer lever arm on one side of the rod than it does on the other. The side of the rod farthest from the fulcrum has more torque acting on it
  + The rod tilts towards the side that has more torque
* Rotational equilibrium = the state in which the sum of the torques acting on an object is zero
* Example 6.4 p.195-196
  + Two children are playing on a seesaw. They get a little tired rocking back and forth, so they decide to balance the seesaw. One child weighs 201 Newtons and sits 1.30m from the center of the seesaw. The other finds that he must be 1.00m from the center of the seesaw to achieve balance. What does he weigh?
* In rotational equilibrium problems, we will always ignore the weight of the thing that is rotating.
* Torques that cause clockwise motion are considered negative torques, while torques that cause
* OYO p.196-197 #6.6-6.7

Objects on an Inclined Surface

* Determining the parallel and perpendicular components of gravity on an inclined surface can be found using a free body diagram.
  + A sketch of force vectors on an object
  + Figure 6.3 p.198 diagram of skier
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* The component of an object’s gravitational force that runs parallel to an inclined surface is equal to the weight of the object times the sine of the incline angle
  + Parallel component = w \* sin(Ө)
* The gravitational component perpendicular to the surface is equal to the weight of the object times the cosine of the incline angle
  + Perpendicular component = w \* cos(Ө)
* Experiment 6.3 p.198
  + Read p199-200 and calculate the angle of the incline, and the coefficient of static friction.
* Example 6.5 p.201-202
  + A 35-Newton block slides down a board that is inclined at 30°. If the coefficient of kinetic friction between the block and the board is 0.12, what is the block’s acceleration?
* OYO p.202 #6.8-6.9

Applying Newton’s Second Law to More than one Object at a Time

* Example 6.6 p.203-204 (read through and copy down into your notes)
  + Two toy cars (3.5 kg and 4.5 kg) are tied together with a piece of string. If a child pulls the lead car with a 3.2 Newton force, what acceleration will the two cars experience? What will be the tension in the string? You may ignore friction in this problem.
* First we determine all the forces acting on the objects
* Then consider each object individually
* Each object provides an equation
* Solve the equations simultaneously
* OYO p.205 #2.10