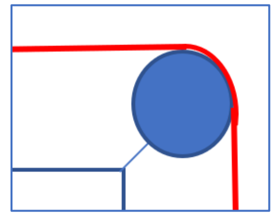
Rotation with Translation (use g = 32.2 ft/s² m = 9.81/s²)

1. Atwood's and similar machines : When looking at the pulley wheel(s), ask yourself whether you need "T_1 and T_2" or just one Tension.

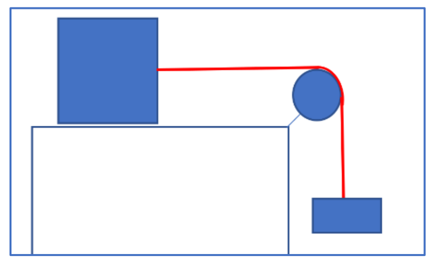


a) The "frictionless" pulley wheel to the right has I = 10 kg*m^2, radius 50 cm and clockwise angular acceleration 2 rad/s^2. The tension in the horizontal section of rope is 50 N. Find the tension in the vertical section of rope.

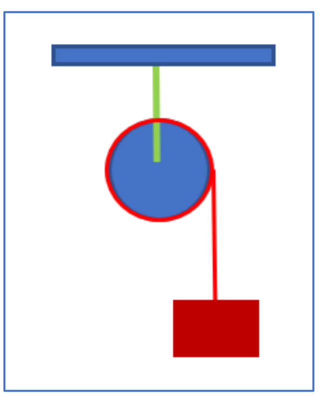
b) Same wheel, same tension in horizontal section, but now wheel turns CCW with constant angular speed 60 rpm. Find the tension in the vertical section of rope.

c) Suppose the pulley wheel is still frictionless but now is virtually massless, with radius 50 cm and I = .001 kg*m^2. The wheel has clockwise angular acceleration 2 rad/s^2. Find the tension in the vertical section of rope. (Your conclusion should be that in this case you the tensions are basically equal, so you do not need T_1 and T_2 you can just call both tensions "T").

2. The block on the plane has mass 60 kg; the coefficient of kinetic friction between the block and the plane is 0.15. The pulley wheel is frictionless and massless and the rope is light. The hanging mass is 40 kg.

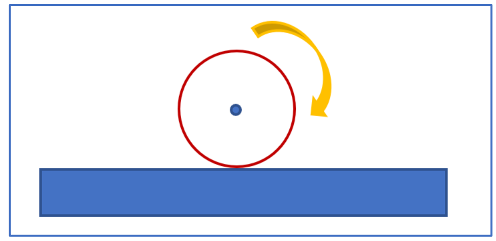


a) Complete 2 FBDs, one of each mass.
b) Write Newton's 2nd in the direction of motion twice, once for the block, once for the mass. You should probably make "right" the positive direction for the block and down positive for the mass so that the each has the same acceleration a.
c) Two equations and two unknowns! Solve for the rope tension and the acceleration.
d) Check your tension. Does the "T" you found give the block the correct acceleration? Does it give the hanging mass the correct and same acceleration?



3. *(This is also can be made into a "2 equations, 2 unknowns" problem)*. The pulley wheel is frictionless but not massless; it has moment of inertia 4 slug-ft^2 and dimeter 6 inches. The hanging block has weight 32.2 pounds. The hanging block is released from rest.

a) Complete 2 FBDs, one of the pulley wheel and one of the block.
b) Write Newton's 2nd in the direction of motion twice, once for the block and once for the mass. For the block, you may want to make down the positive direction as it's acceleration is downwards.
c) You may have 2 equations and 3 unknowns! If so, your needed 3rd equation relates the block's "a" to the wheel's α: $\alpha = a/r$. Use your equations to solve for the rope tension, the block acceleration, and the wheel angular acceleration.
d) Check your tension. Does the "T" you found give the block the correct acceleration? Does it give the wheel the correct angular acceleration? Is the magnitude of the tangential acceleration of a point on the wheel's rim the same as the magnitude of the block's acceleration?



4. (Wheel acceleration without slipping). Here two you will have two equations and two unknows. The wheel can be considered a solid disk with mass 8 kg and diameter 1 meter. A "dot" at it's center represents a shaft coming from a motor; the shaft exerts a 10 N-m clockwise torque on the wheel. The wheel rolls to the right without slipping.

a) Complete a FBD of the wheel. Your forward force should be at the point where the wheel meets the road; should it be static or kinetic friction?

b) Write Newton's law twice for the wheel. One equation should be the translational version, the other the rotational version. The rotational version should have two moments (or torques).

c) You may have two equations and three unknowns. You can also use the equation $\alpha_{wheel} = a_{cm}/r$ where a_{cm} represents the translational acceleration of the wheel (i.e. the acceleration of it's center of mass).

d) Solve your equations for the wheel's translational acceleration, angular acceleration and the frictional force on the wheel.

e) Check the friction force you calculated. Does it give the wheel the correct translation acceleration? The correct angular acceleration?

f) Suppose the wheel has the maximum acceleration possible without slipping. What is the coefficient of friction between the wheel and the road? Is this a kinetic or a static coefficient?