Your Name: ____________________________

Teammates: ____

Physics 8, Fall 2021, Worksheet #15.

`http://positron.hep.upenn.edu/p8/files/ws15.pdf`

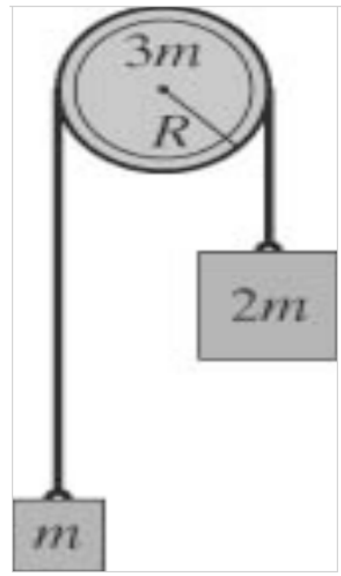
Upload PDF (smartphone scan or tablet edit) to Canvas shortly after class on Mon, Oct 25, 2021.

Problems marked with (*) must include your own drawing or graph representing the problem and at least one complete sentence describing your reasoning.

Discuss each problem with your teammates, then write up your own solution. Be sure to compare final results with your teammates, as a way to catch mistakes. It can also be very interesting when you and a teammate use different methods to arrive at a result! Do not hesitate to ask for help from other students, from Melina, or from Bill.

1*. You have a pail of water with a rope tied to the handle. If you whirl it fast enough in a vertical circle (i.e. a circle whose central axis is horizontal), none of the water spills out of the bucket, even when the bucket is upside down. (a) Explain how this works. (b) If the bucket rotates at constant speed v on the end of a rope of length ℓ, what minimum speed is required to keep the water from falling out of the pail? (c) If you plug in $\ell = 1.0\,\mathrm{m}$, what number of **revolutions per second** (that's $\omega/(2\pi)$, or $v/(2\pi\ell)$) does this speed correspond to? (You may remember that I spun the bucket about two or three times faster than this in the lecture demo. For simplicity, assume that my arm contrives to keep the motion at constant speed, in spite of the change in height between top and bottom.) (d) Assuming that my arm somehow manages to twirl the bucket in a circle at constant angular velocity (thus constant speed), without the water spilling, draw a FBD for the water when the pail is upside-down (12 o'clock position), and (e) when the pail is rightside-up (6 o'clock position), and (f) when the pail is horizontal (9 o'clock position). After figuring out how big the acceleration vector needs to be for (d), make the acceleration vector the same length in (e) and (f). Be sure to indicate $\vec{a}$ (or probably $m\vec{a}$ is more helpful for scale) on your FBDs.

2*. A block of mass m is attached to a block of mass $2m$ by a very light string hung over a uniform disk of mass $3m$ and radius R that can rotate on a horizontal axle, as shown below (left). The disk's outer surface is rough, so the string and the outer surface of the disk move together without slipping. The lower block is held so that the string is taut, and then the blocks are released from rest. What is the speed of the block of mass m after it has risen a distance h? Ignore any friction between disk and axle. [Hint: since we consider dissipative forces to be negligible here, you can use the fact that total mechanical energy (translational kinetic, rotational kinetic, plus gravitational potential) is constant during the motion. For a solid disk of mass M and radius R, rotational inertia is $\frac{1}{2}MR^2$.]



3*. The spacecraft in the movie 2001: A Space Odyssey has a rotating cylinder to create the illusion of gravity, inside of which the crew walks and exercises. (a) If the radius of the cylinder is 8.0 meters, what should the rate of revolution of the cylinder be in order to replicate Earth's gravity at this radius? (b) For a person, of height 1.65 meters, standing in this cylinder, how does the "gravitational" acceleration at the top of her head compare with the "gravitational" acceleration at her feet? (Might this be uncomfortable?)

4. Assume that Earth's orbit around the Sun is a perfect circle (it's really an ellipse, but to a good approximation it's a circle). Earth's mass is 5.97×10^{24} kg, the radius of its orbit is 1.50×10^{11} m, and its orbital period is 365.26 days. (a) What is the magnitude of Earth's centripetal acceleration as it revolves about the Sun? (b) What are the magnitude and direction of the force necessary to cause this acceleration.