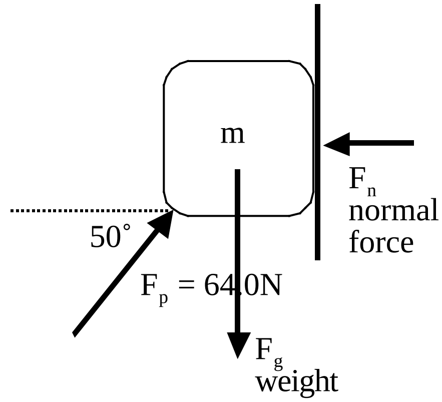
Name:____

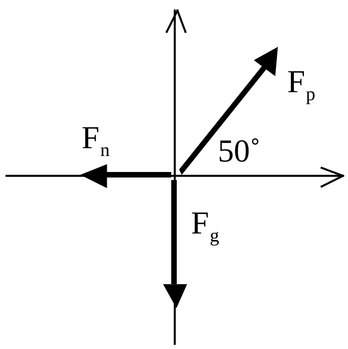
Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles, which are on the last page. Your score will be maximized if your work is easy to follow because partial credit will be awarded.

1. A block is held up against a smooth wall by a person pushing upward and toward the right with a force of 64.0N at an angle of 50˚ below the horizontal as shown. (a)Name and indicate in the drawing the direction of the other forces that are acting on the block and (b)find their magnitudes. (c)Find the mass of the block.



(a)See drawing –no friction because the wall is "smooth."

(b)Free body diagram:



Applying newton's Second Law to each direction separately,

$\Sigma F_x = ma_x \quad F_p\cos 50^\circ - F_n = 0 \quad F_n = F_p \cos 50^\circ$.

$\Sigma F_y = ma_y \quad F_p\sin 50^\circ - F_g = 0 \quad F_g = F_p \sin 50^\circ$.

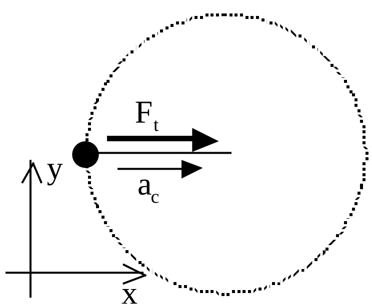
Plugging in the numbers,

$F_n = F_p\cos 50^\circ = (64.0)\cos 50^\circ \quad \boxed{F_n = 41.4N}$.

$F_g = F_p\sin 50^\circ = (64.0)\sin 50^\circ \quad \boxed{F_g = 49.0N}$.

(c)Using the mass/weight rule, $F_g = mg \quad m = \dfrac{F_g}{g} = \dfrac{49.0}{9.80} \quad \boxed{m = 5.00kg}$.

2. A 50.0g ball is twirled overhead at the end of a 35.0cm string. The string will break when the tension exceeds 15.0N. Neglecting vertical forces such as gravity, find (a)the maximum speed that the ball may have without the string breaking and (b)the maximum number of revolutions per minute that the string can withstand.



(a)The only force acting on the ball is the tension in the string (if gravity is ignored). Applying the Second Law.

$$\Sigma F_x = ma_x \quad F_t = ma_c.$$

The centripetal acceleration is related to the speed,

$$a_c = \frac{v^2}{r} \quad F_t = m\frac{v^2}{r} \quad v = \sqrt{\frac{rF_t}{m}} = \sqrt{\frac{(0.350)(15.0)}{0.0500}} \quad \boxed{v = 10.2m/s}$$

(b)Using the definition of speed, $v \equiv \dfrac{\Delta x}{\Delta t} = \dfrac{2\pi r}{T} = 2\pi r f \quad f = \dfrac{v}{2\pi r} = \dfrac{10.2}{2\pi(0.35)} = 4.66\,\frac{rev}{s}$.

Converting the units, $f = 4.66\,\frac{rev}{s}\left(\dfrac{60s}{\min}\right) \quad \boxed{f = 280rpm}$.

3. A woman throws a ball of mass 0.200kg by accelerating it from rest to 30.0m/s over a distance (assumed to be along a straight line) of 85.0cm. Find (a)the initial kinetic energy of the ball, (b)the final kinetic energy of the ball, (c)the work done on the ball by the woman and (d)the average force exerted on the ball by the woman.

(a)Using the definition of kinetic energy, $K \equiv \frac{1}{2}mv^2$ $K_i = \frac{1}{2}mv_i^2 = \frac{1}{2}(0.200)(0)^2$ $\boxed{K_i = 0}$.

(b)Using the def'n of kinetic energy, $K \equiv \frac{1}{2}mv^2$ $K_f = \frac{1}{2}mv_f^2 = \frac{1}{2}(0.200)(30.0)^2$ $\boxed{K_f = 90.0J}$.

(c)Applying the Work-Energy Theorem, $W_{net} = \Delta K$ $W = K_f - K_i = 90 - 0$ $\boxed{W = 90.0J}$.

(d)Using the definition of work,

$$W \equiv \int \vec{F} \cdot d\vec{s} \qquad W \approx F_{av}\Delta s \qquad F_{av} = \frac{W}{\Delta s} = \frac{90.0}{0.850} \qquad \boxed{F_{av} = 106N}.$$

4. A bug flying northward at 8.00m/s collides with the windshield of a car traveling southward at 20.0m/s. Answer the following questions. For full credit, you must explain your thinking. Be sure to cite any relevant principles of physics. Which object, the bug or the car:

(a)feels the greater force during the collision? BOTH THE SAME

By Newton's Third Law, both objects (the bug and the car) feel the same force.

(b)has the greater acceleration during the collision? BUG

By Newton's Second Law, the bug will accelerate more under the effect of the same force because it has the smaller mass.

(c)has the greater work done on it during the collision? BOTH THE SAME

The definition of work is force times distance. Since both feel the same size force and the force acts over the same distance during the collision, they both have the same amount of work done on them.

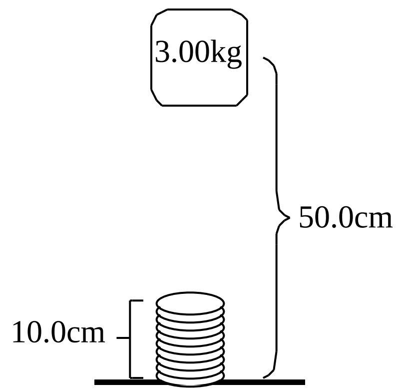
(d)has the greater change in kinetic energy during the collision? BOTH THE SAME

By the Work-Energy Theorem, if they both have the same work done, then they will both have the same change in kinetic energy.

(e)has the greater kinetic energy after the collision? CAR

The definition of kinetic energy is half the mass times the square of the speed. After collision, they are both traveling at the same speed. Since the bug has the smaller mass, it must have the smaller kinetic energy.

5. A 3.00kg block is released from rest and drops vertically from a height of 50.0cm on to a 10.0cm tall spring. The spring compresses 6.00cm when the block is again (temporarily) at rest. Find the spring constant of the spring.



Initially,

$K_i = 0$ and $U_i = U_g = mgh_i$

When the spring in compressed,

$K_f = 0$ and $U_f = U_s + U_g = \frac{1}{2}kx^2 + mgh_f$

Note that:

$h_i = 0.500m$
$h_f = 0.040m$ because the block doesn't fall all the way to the ground due to the spring.
$x = 0.0600m$

Using the Law of Conservation of Energy,

$\Delta K + \Delta U = 0 \quad (0-0) + (\frac{1}{2}kx^2 + mgh_f - mgh_i) = 0$

Solving for the spring constant,

$$k = \frac{2mg(h_i - h_f)}{x^2} = \frac{2(3.00)(9.80)(0.500 - 0.040)}{(0.0600)^2} \quad \boxed{k = 7510N/m}.$$