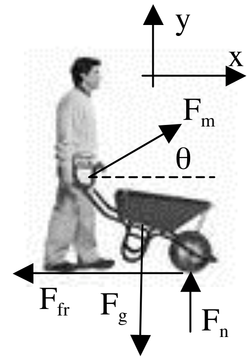
Name:____

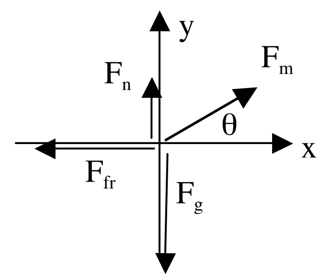
Solve the following problems in the space provided. Use the back of the page if needed. Each problem is worth 20 points. You must show your work in a logical fashion starting with the correctly applied physical principles. The equations you need are on the equation sheet. Your score will be maximized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



1. The man at the right pushes a 15.0kg wheelbarrow at a constant speed of 0.750m/s. The normal force that the ground exerts on the wheel is 80.0N and the frictional force that the ground exerts on the wheel is 25.0N. Find the magnitude and direction of the force exerted by the man on the wheelbarrow.

Since the velocity is constant the acceleration is zero. Applying Newton's Second Law,

$$\Sigma\vec{F} = m\vec{a} \Rightarrow \begin{cases} \Sigma F_x = ma_x \Rightarrow F_m\cos\theta - F_{fr} = 0 \\ \Sigma F_y = ma_y \Rightarrow F_m\sin\theta + F_n - F_g = 0 \end{cases}$$



Using the mass/weight rule and solving for the force exerted by the man,

$$F_m\cos\theta = F_{fr} = 25.0N$$
$$F_m\sin\theta = F_g - F_n = mg - F_n = (15.0)(9.80) - 80 = 67.0N$$

Using the Pythagorean Theorem and the definition of tangent,

$$F_m = \sqrt{(F_m\cos\theta)^2 + (F_m\sin\theta)^2} = \sqrt{(25.0)^2 + (67.0)^2} \Rightarrow \boxed{F_m = 71.5N}.$$
$$\tan\theta = \frac{F_m\sin\theta}{F_m\cos\theta} = \frac{67.0}{25.0} \Rightarrow \theta = \arctan\frac{67.0}{25.0} \Rightarrow \boxed{\theta = 69.5^\circ}.$$

2. Tarzan has a mass 0f 80.0kg and swings from the end of a 4.00m long vine. At the bottom of his swing he is moving at 6.00m/s. Find (a)the magnitude and direction of his acceleration and (b)the tension in the rope at this instant.

(a)Since the motion is circular, the acceleration is centripetal,

$$a_c = \frac{v^2}{r} = \frac{(6.00)^2}{4.00} \Rightarrow \boxed{a_c = 9.00m/s^2}.$$

The direction is toward the center of the circle, which is straight upward along the rope.

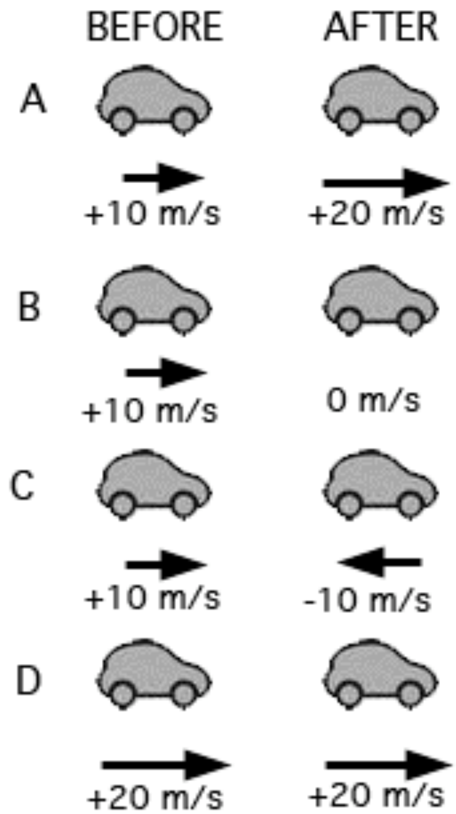
(b)Applying Newton's Second Law,

$$\Sigma F = ma \Rightarrow F_t - F_g = ma_c$$

Using the mass/weight rule and solving for the tension,

$$F_t - mg = ma_c \Rightarrow F_t = mg + ma_c = m(g + a_c) = (80.0)(9.8 + 9.00) \Rightarrow \boxed{F_t = 1500N}.$$

3. The four situations to the right show before and after "snapshots" of a car's velocity. Rank these situations, in terms of the total work done on the car required to create these changes in velocity, from most positive to most negative, All cars have the same mass. Explain your reasoning for full credit.



The Work-Energy Theorem states that the total work done is equal to the change in kinetic energy. Calculating the change in kinetic energy in each case can be done using the definition of kinetic energy,

Case A: $\Delta K_A = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}m(20)^2 - \frac{1}{2}m(10)^2 = 150m$

Case B: $\Delta K_B = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}m(0)^2 - \frac{1}{2}m(10)^2 = -50m$

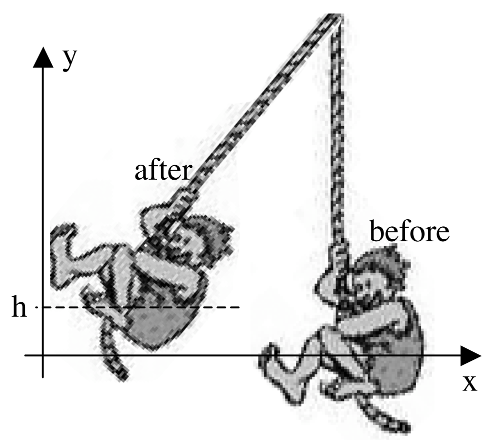
Case C: $\Delta K_C = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}m(-10)^2 - \frac{1}{2}m(+10)^2 = 0$

Case D: $\Delta K_D = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}m(20)^2 - \frac{1}{2}m(20)^2 = 0$

The ranking is, A>C=D>B.

4. Referring back to Tarzan from problem 2, find the maximum height above the bottom of the swing that he will be able to reach.

Using the coordinates shown, the initial energy is all kinetic,
$K_o = \frac{1}{2}mv_o^2$ and $U_o = 0$.

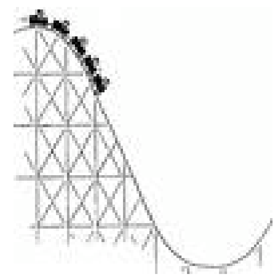


At the maximum height, all the energy is potential,
$K = 0$ and $U = mgh$.

Applying the Law of Conservation of Energy,
$\Delta K + \Delta U = 0 \Rightarrow (K - K_o) + (U - U_o) = 0 \Rightarrow K_o = U$

Plugging in from above,
$\frac{1}{2}mv_o^2 = mgh \Rightarrow h = \frac{v_o^2}{2g} = \frac{(6.00)^2}{2(9.80)} \Rightarrow \boxed{h = 1.84m}$.

5. The roller coaster show at the right is filled with riders and has a total mass of 2000kg. At the top of the 40.0m high hill it is moving at 6.00m/s. At the bottom it has a speed of 22.0m/s. (a)Describe at least two non-conservative forces that might be acting on the roller coaster and (b)find the total work done by all non-conservative forces.



(a)Air resistance probably plays a strong role as a non-conservative force. Friction between the wheels and the track might also cause an effect.

(b)Initially, the energy is both kinetic and potential,
$K_o = \frac{1}{2}mv_o^2 = \frac{1}{2}(2000)(6.00)^2 = 36.0kJ$ and $U_o = mgh = (2000)(9.80)(40.0) = 784kJ$.

At the bottom, all the energy is kinetic,
$K = \frac{1}{2}mv^2 = \frac{1}{2}(2000)(22.0)^2 = 484kJ$ and $U = 0$.

Applying the Law of Conservation of Energy,
$\Delta K + \Delta U = W_{nc} \Rightarrow W_{nc} = (K - K_o) + (U - U_o) = (484 - 36.0) + (0 - 784) \Rightarrow \boxed{W_{nc} = -336kJ}$.