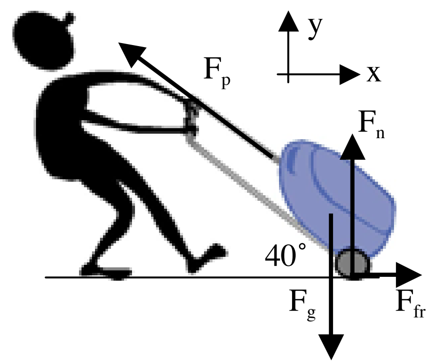
Name:____

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 20.0kg suitcase is pulled with a force of 60.0N at an angle of 40.0° above horizontal. The resulting acceleration is 1.00m/s^2. (a)Show the direction of each force that acts on the suitcase in the drawing at the right. (b)Find the magnitude of each force.



Applying Newton's Second Law to each direction,

$\Sigma F_x = ma_x \Rightarrow F_{fr} - F_p \cos 40° = ma_x$

$\Sigma F_y = ma_y \Rightarrow F_n + F_p \sin 40° - F_g = 0$

Given $\boxed{F_p = 60.0N}$.

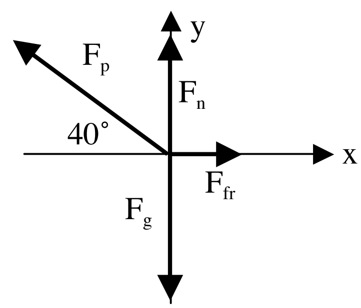
Using the mass/weight rule, $F_g = mg = (20.0)(9.80) \Rightarrow \boxed{F_g = 196N}$.

Solving the x-equation for the frictional force,

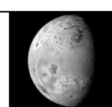
$F_{fr} = ma_x + F_p \cos 40° = (20.0)(-1.00) + 60.0\cos 40° \Rightarrow \boxed{F_{fr} = 26.0N}$

Solving the y-equation for the normal force,

$F_n = F_g - F_p \sin 40° = 196 - 60.0 \sin 40° \Rightarrow \boxed{F_n = 157N}$



2. Below is a table of some data about four moons of Jupiter discovered by Galileo. Rank these moons in order of the magnitude of their acceleration. That is, rank first the one with the highest acceleration and rank last the one with the smallest acceleration. Explain your reasoning.

Moon	Orbital Radius (x10^{6}m)	Orbital Speed (x10^{3}m/s)	Image
Io	422	17.3	
Callisto	1883	8.20	
Ganymede	1070	10.9	
Europa	671	13.7	

These moon are in circular orbit around Jupiter so the experience centripetal acceleration which is given by,

$$a_c = \frac{v^2}{r}.$$

Io: $a_c = \frac{v^2}{r} = \frac{(17.3)^2}{422} = 0.709$

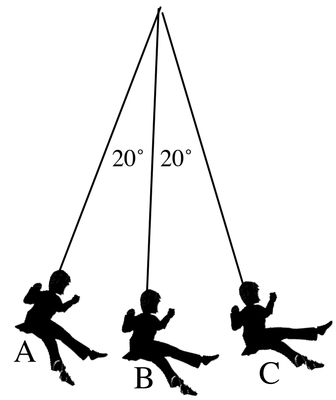
Callisto: $a_c = \frac{(8.20)^2}{1883} = 0.036$

Ganymede: $a_c = \frac{v^2}{r} = \frac{(10.9)^2}{1070} = 0.111$

Europa: $a_c = \frac{v^2}{r} = \frac{(13.7)^2}{671} = 0.280$

The ranking is: $\boxed{\text{Io >Europa> Ganymede> Callisto}}$

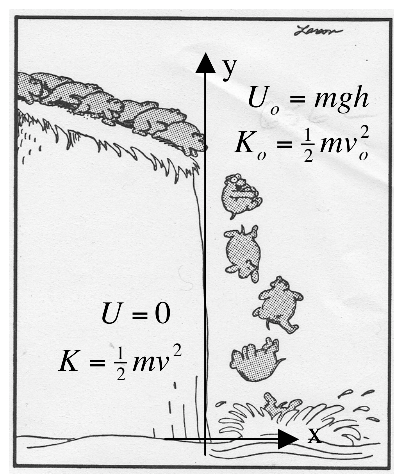
3. A 30.0kg child on a 2.00m long swing moves back and forth through a 40° angle (20° on each side of the vertical). Find the work done by the tension, the work done by gravity and the total work done on the child as she moves from (a)A to B, (b)B to C, and (c)A to C.



Since the tension is always perpendicular to the motion, it does no work.
Since the force of gravity is always vertical, the work done by gravity will just be the gravitational force times the vertical distance traveled.
Using the definition of work, $W \equiv \int \vec{F} \bullet d\vec{s} \Rightarrow W_g = \int mgdy = mg\Delta y$.
Note that positive work will be done from A to B because the force and motion are in the same direction, while negative work will be done from B to C. No work will be done from A to C because the height doesn't change.
The tricky part is finding the change in height, $\Delta y = \ell - \ell \cos 20° = 2.00 - 2.00 \cos 20° = 0.121m$
Calculating the work,
$W_g = mg\Delta y = (30.0)(9.80)(0.121) = 35.5J$
Since the work done by tension is always zero, the total work is just the work done by gravity.

Motion	Work by tension	Work by gravity	Total work
A to B	0	35.5J	35.5J
B to C	0	-35.5J	-35.5J
A to C	0	0	0

4. The lemmings shown at the right leave the top of a 4.00m high cliff with a speed of 3.00m/s at an angle of 70.0° below horizontal. Find the speed at which they hit the water.

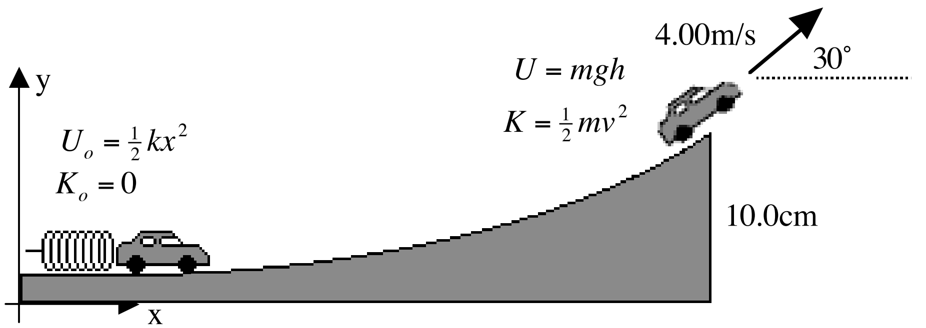


Applying the Law of Conservation of Energy,
$\Delta K + \Delta U = 0 \Rightarrow (K - K_o) + (U - U_o) = 0$.

Substituting the energies shown at the right,
$(\frac{1}{2}mv^2 - \frac{1}{2}mv_o^2) + (0 - mgh) = 0$.

Canceling the mass and solving for the final speed,
$v = \sqrt{v_o^2 + 2gh} = \sqrt{(3.00)^2 + 2(9.80)(4.00)} \Rightarrow \boxed{v = 9.35m/s}$.

5. A child's toy shown below consists of a spring (k = 2000N/m) that when released from a compression of 3.00cm sends a 75g toy car up a 10.0cm high ramp and launches the car at 4.00m/s at an angle of 30˚ above horizontal. (a)Name at least two non-conservative forces that might be acting on the car between the time it leaves the spring and the time it leaves the ramp. (b)Find the total work done by all the non-conservative forces.



(a)Non-conservative forces might include friction and air resistance.

(b) Applying the Law of Conservation of Energy,
$\Delta K + \Delta U = W_{nc} \Rightarrow (K - K_o) + (U - U_o) = W_{nc}$.

Substituting the energies shown at the right,
$(\frac{1}{2}mv^2 - 0) + (mgh - \frac{1}{2}kx^2) = W_{nc}$.

Plugging in the numbers,
$W_{nc} = \frac{1}{2}(0.075)(4.00)^2 + (0.075)(9.80)(0.100) - \frac{1}{2}(2000)(0.0300)^2 \Rightarrow \boxed{W_{nc} = -0.227J}$.