Problem 1: Block A (M_A=10kg) slides across a frictionless surface as a Force F is applied to Block A, as shown in the figure below. A second block (Block B, M_B=5kg) sits above Block A. There is friction between the top of Block A and the bottom of Block B (μ_s=0.6, μ_k=0.4).

(a) Draw the free body diagrams for each block.

(b) What is the maximum Force which can be applied to this system without Block B slipping?

$\vec{F}_{max}$ =_______________

(c) What is the acceleration of the system for this Force (assuming Block B is not slipping)?

$\vec{a} =$ ________________

(d) Assume the force applied is now F=120N. What are the accelerations of Blocks A and B?

$\vec{a}_A =$ ________________

$\vec{a}_B =$ ________________

Problem 2: A block (m=20kg) rests on an inclined plane (θ=30°). The coefficients of friction between the block and the plane are μ_s=0.5, μ_k=0.4.

a) Draw the free body diagram for the block, including your coordinate system and all forces acting on the block.

b) What is the Normal Force acting on the block?.

$$\vec{F}_N = \underline{\hspace{5cm}}$$

c) What is the acceleration of the block?

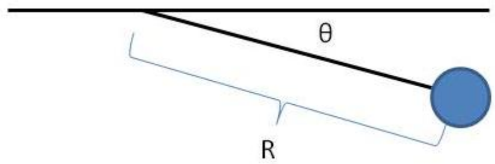
$\vec{a}$ = ____________________

d) Suppose you don't want the block to accelerate. To prevent this, you apply a Force to the block parallel to the surface of inclined plane. What should this Force be to i) prevent the block from moving and ii) keep the block moving at a constant speed?

$i)\ \vec{F}_{applied}$ = _____________

$ii)\ \vec{F}_{applied}$ = _____________

Problem 3: A mass (M=1.5kg) is attached to a massless cord of length R=2m. The mass rotates around the vertical axis with a constant θ=15°.



a) Draw the free-body diagram for the mass

b) What is the tension in the cord?

$|\vec{T}| =$ ______________

c) What is the centripetal acceleration of the mass?

a_c=________________

d) What is the speed of the mass and the period and frequency of the mass's rotation?

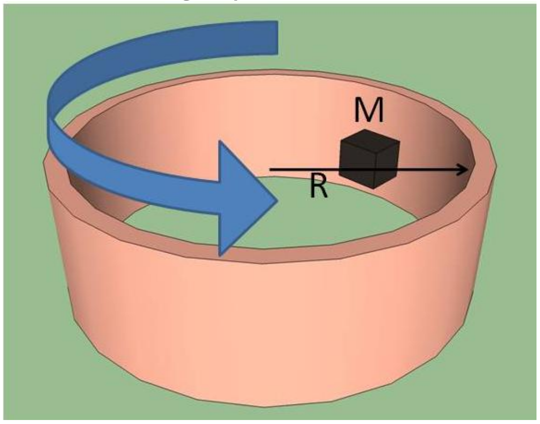
v=________________

T=________________

f=________________

e) If the length of the cord is halved, but the angle θ remains unchanged, what is the new period of the mass's motion?

Problem 4: A ring of radius 5m, shown below, rotates with a constant angular velocity ω=4rad/s. A mass sits on the inside wall of the ring. The coefficient of friction between the mass and the inside wall of the ring is μ_s.



a) What is the speed and acceleration of the mass?

v=_____

a=_____

b) Draw the free body diagram for the mass.

c) What is the minimum possible value for μ_s which will allow the mass to rotate without slipping?

$\mu_{\text{min}} =$ ________

d) Suppose it starts raining, and the new coefficient of static friction for the wet wall of the ring is μ_s=0.1. The angular velocity of the ring changes to ensure the mass does not slip. What would be the minimum acceleration (how many g's) the mass experiences if it rotated without slipping?

a ________

Problem 5: A planet has radius $R=1x10^6$m and Mass $Mp=5x10^{23}$kg.

a) What is the acceleration due to gravity at the surface of the planet?

b) A ball is thrown horizontally, at the surface of this planet, such that it begins to orbit the planet. What is the ball's speed?

$v_{surface}$=__________________

c) What would be the speed of the ball if it was orbiting 100km above the surface of the planet?

v_{100km}=__________________

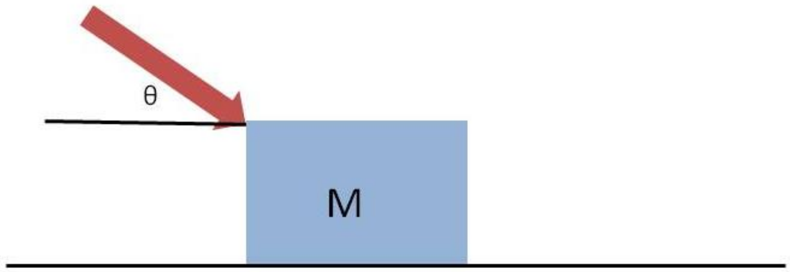
d) With what initial velocity would a ball need to be launched in order to escape the gravitational field of the planet?

v_{launch}=__________________________

e) For the situation in (d), what would the speed of this ball be 100km above the surface of the planet??

v=_______________

Problem 6: A crate of mass M=7kg is pushed across a surface with μ_k=0.3 by a constant force of F=40N at an angle θ=25°, as shown in the figure below.



a) Draw the free body diagram for the crate, showing all forces, and your coordinate system.

b) What is the acceleration of the crate, and how long does it take the crate to travel 25m?

a=________________

t=________________

c) What is the work done by the applied force over those 25m?

W_{force}=________________

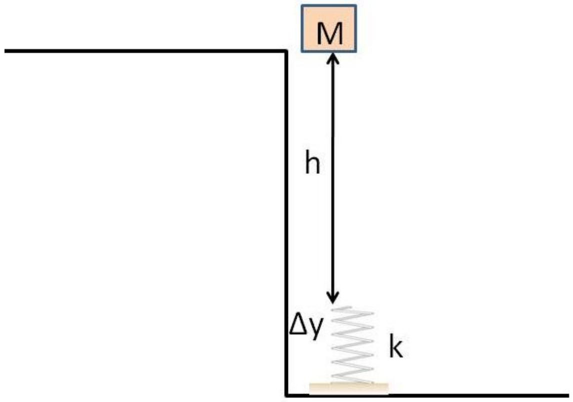
d) What is the work done by friction over the same distance?

$W_{friction}$=________________

e) Using the Work-Energy principle, determine the speed of the crate after 25m.

v=________________

Problem 7: A mass (M=3kg) is dropped off of a cliff. It lands on a spring with spring constant k=2,500 N/m a distance h=30m below.



a) What is the speed of the mass when it hits the spring?

v=________________

b) Give the gravitation potential and kinetic energy of the mass, and the potential energy of the spring, at the point where the spring is its most compressed (a distance Δy), in terms of g, Δy, k, and m.

U_s=________________

U_g=________________

KE=________________

c) What is the distance Δy?

Δy =_______________

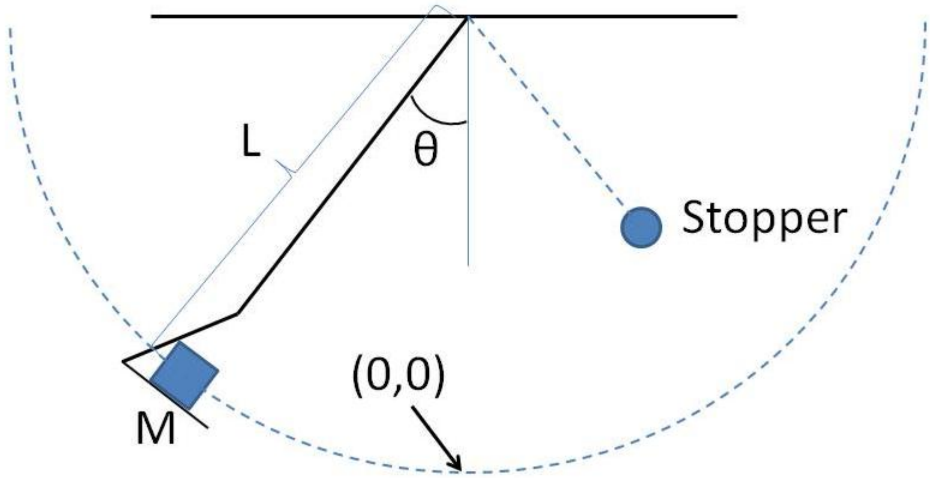
d) How much work is done by the spring from the moment the mass hits the spring to when the spring is fully compressed?

W_{spring}=_______________

e) If the mass bounces off of the spring up to maximum height which is 7 meters below its original drop point, how much mechanical energy is lost?

Energy Lost=_______________

Problem 8: A mass M=2kg sits on a swing held to a swivel point by a solid rod of length L=2.5m. The swing is released from rest at an angle of θ =90°.



a) What is the speed of the mass at θ =0° (when the mass is at the origin)?

v=_______________

b) What is the Normal Force exerted on the mass (by the swing) at θ =0° (when the mass is at the origin)?

$\vec{F}_N =$ _____________

c) A stopper is positioned so as to stop the swing at an angle of θ =-40° (on the right side of the swing). The mass is launched from this point. Give the initial speed, launch angle, and launch position of the mass.

v_{launch} =________________

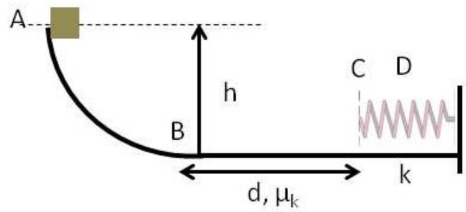
θ_{launch} =________________

$\vec{r}_{launch}$ =________________

d) Where does the mass land? (assume the ground is y=0m)

R=________________

Problem 9: A mass M=3kg starts from rest and slides down (h=10m) a frictionless surface and smoothly transitions to a flat surface with coefficient of static friction μ_k=0.4. The mass travels a distance d=10m on this surface and then hits a spring with k=400N/m. The surface under the spring is frictionless.



a) What is the speed of the mass at points B?

v_B=________________

b) What is the speed of the mass at point C, and how much thermal energy has been generated between B and C?

v_C=________________

$E_{thermal}$=________________

c) What is the maximum compression of the spring?

$\Delta x_{\text{max}} =$ ______________

d) The spring pushes the mass back towards its starting position. Does the spring make it back to the slide (past point B)? If so, how high does the mass make it before turning around? If not, where does the mass stop? SHOW WORK!