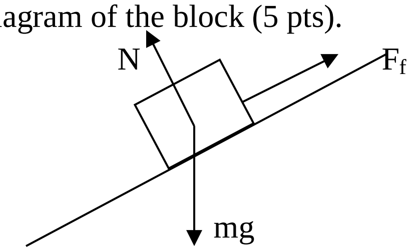
Part II: Problems: ***Show all work and/or reasoning for full credit***. Please answer all parts. (70 points total – individual points for parts shown)

1. A 5 kg block slides down a 30^o rough inclined plane with a coefficient of kinetic friction of 0.2. (22 pts)

a) Draw a free body diagram of the block (5 pts).



b. Write down the equations of motion assuming the block moves and find its acceleration down the plane(10 pts).

$Mg \sin 30 - \mu_k N = ma$ and $mg \cos 30 - N = 0$

Solving $a = 3.2\ m/s^2$

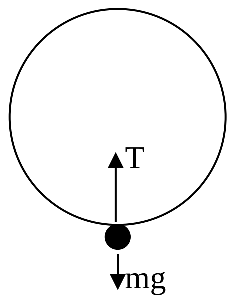
c. What is the minimum coefficient of static friction needed to keep the block from sliding down the plane? (7 pts) *Show all reasoning/work*.

Require $mg\sin 30 - \mu_s\, mg \cos 30 = 0$ use max static friction here to get minimum coef

Solving gives $\mu_s = \tan 30 = 0.58$

2. A 0.1 kg ball is attached to a 0.2 m light cord and spun in a vertical circle. (27 pts)

a) Draw a free-body diagram of the ball at the bottom of the circle. (5 pts)



b) If the ball's velocity at the bottom is 4 m/s, find the cord tension at the bottom from applying Newton's second law. (8 pts)

from free-body diagram above

$T - mg = F_{net} = mv^2/R$ or $T = mg + mv^2/R = 8.98$ N

c) As the ball travels from the bottom to the top, find the work done by gravity *and* by the tension force (*label your answers clearly*). (6 pts)

$W_{gravity} = -mg\,\Delta H = -0.1\,(9.8)\,(0.4) = -0.39$ J

$W_T = 0$ since T is always radial and displacement is tangential – so T is always perpendicular to displacement and does no work

d) Using energy ideas find the ball's speed at the top and then find the tension in the cord at the top. (8 pts)

$E_{top} = E_{bottom}$ so

$(KE + PE)_{top} = (KE + PE)_{bottom}$

or $\frac{1}{2} mv^2_{top} + mgH_{top} = \frac{1}{2} mv^2_{bottom}$

or

$v^2_{top} = v^2_{bottom} - 2g\Delta H$ or with $\Delta H = 0.4$ m and v_{bottom} from above

$v_{top} = 2.86$ m/s

at the top both T and mg are down so $T + mg = F_{net} = mv^2_{top}/R$

or T = 3.1 N

3. A small 2 kg cart slides down a frictionless loop-the-loop track of 1.2 m diameter starting at rest from a height of 2.5 m. (21 pts)

a) Find the velocity of the cart after it emerges from the loop-the-loop along a horizontal track at ground level. (7 pts)

conservation of energy: $E_{start} = PE_{start} = E_{final} = KE_{final}$

$mgH = \frac{1}{2} mv^2$ or v = 7.0 m/s

b) If the cart in part (a) then makes a collision with a 0.5 kg cart initially at rest on the horizontal track, find their final velocity if they stick together – ***state explicitly what principle you use to solve this part***. (7 pts)

conservation of momentum in collision: $P_{init} = P_{final}$

$mv_{init} = (m + M)\, V_{final}$

or $V_{final} = 5.6$ m/s

c) If the two carts in part (b) then hit a stiff horizontal spring with a spring constant of 800 N/m, find maximum distance the spring is compressed. (7 pts)

conservation of energy: $\frac{1}{2} kA^2 = \frac{1}{2} (m + M)\, V^2_f$

so $A = \text{sqrt}[(m + M)/k]\ V_f = 0.31$ m with velocity from part (b)