Physics 160 Fall 09 Midterm Exam 2. **Name:** SOLUTIONS

$\Delta x = v_0 t + \frac{1}{2} a t^2$

$a_R = v^2 / R$

$U_{sp} = \frac{1}{2} k x^2$

$U_{gr} = mgh$

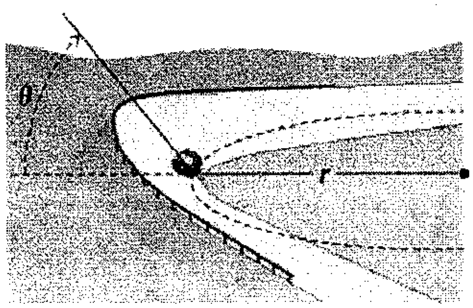
$\sin(30°) = \cos(60°) = \frac{1}{2}$

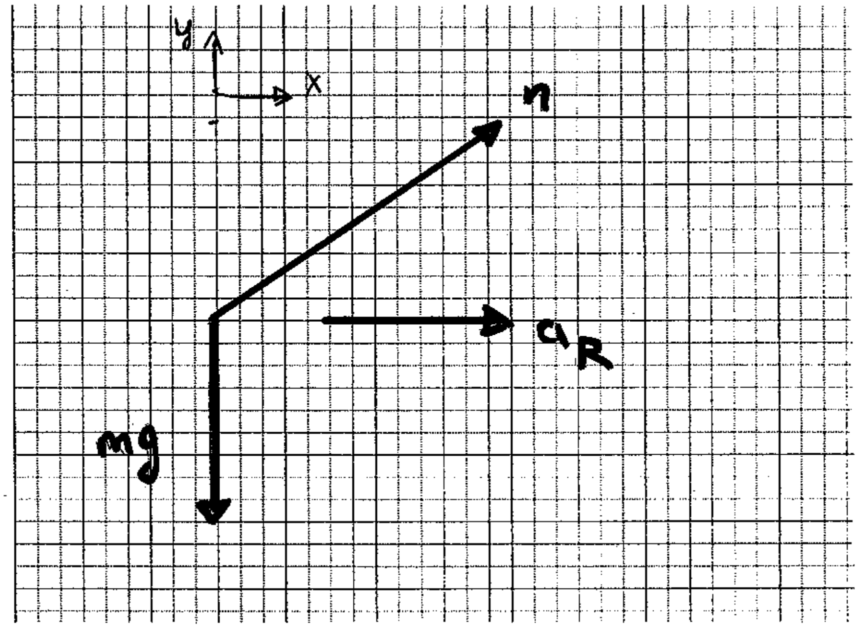
$\cos(30°) = \sin(60°) = \frac{\sqrt{3}}{2}$

Draw Free Body Diagrams. 12pt each. *Make your force vectors proportionately correct in length.*

1. A car going around a banked, icy curve, without slipping, at constant speed.

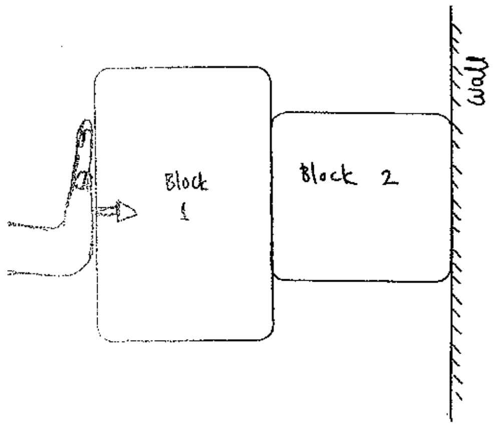
Show also the acceleration(s) of the car, if any.



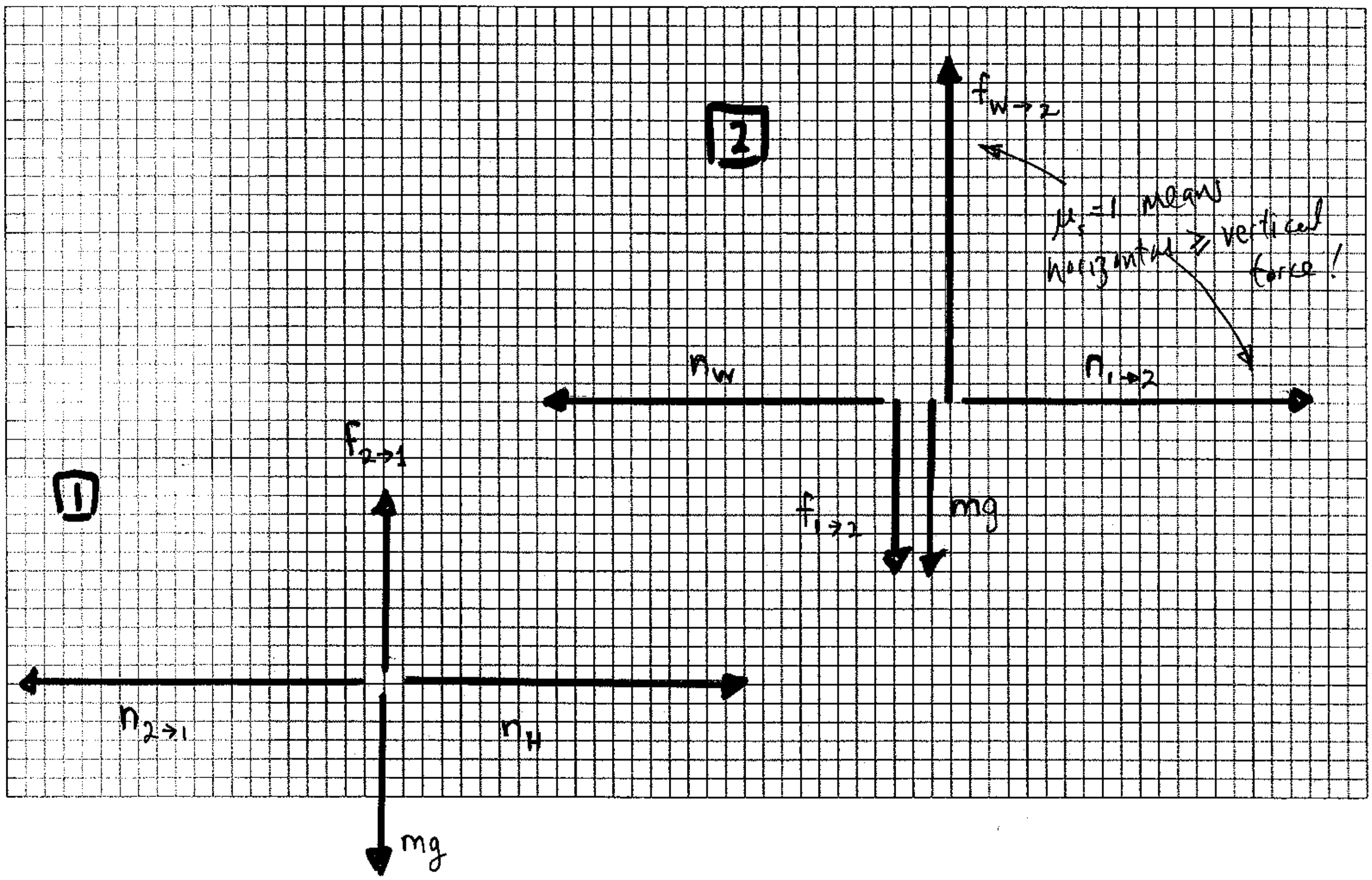


Note that $n_y = mg$!

2. A greasy (frictionless) hand holding two rough blocks, each of mass m, stationary against a rough wall. $\mu_s = 1$ for all rough surfaces. Draw the forces on each block.



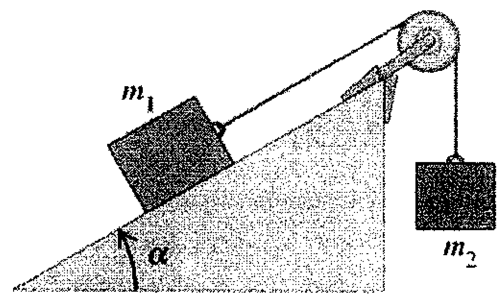
f = friction force
n = normal force



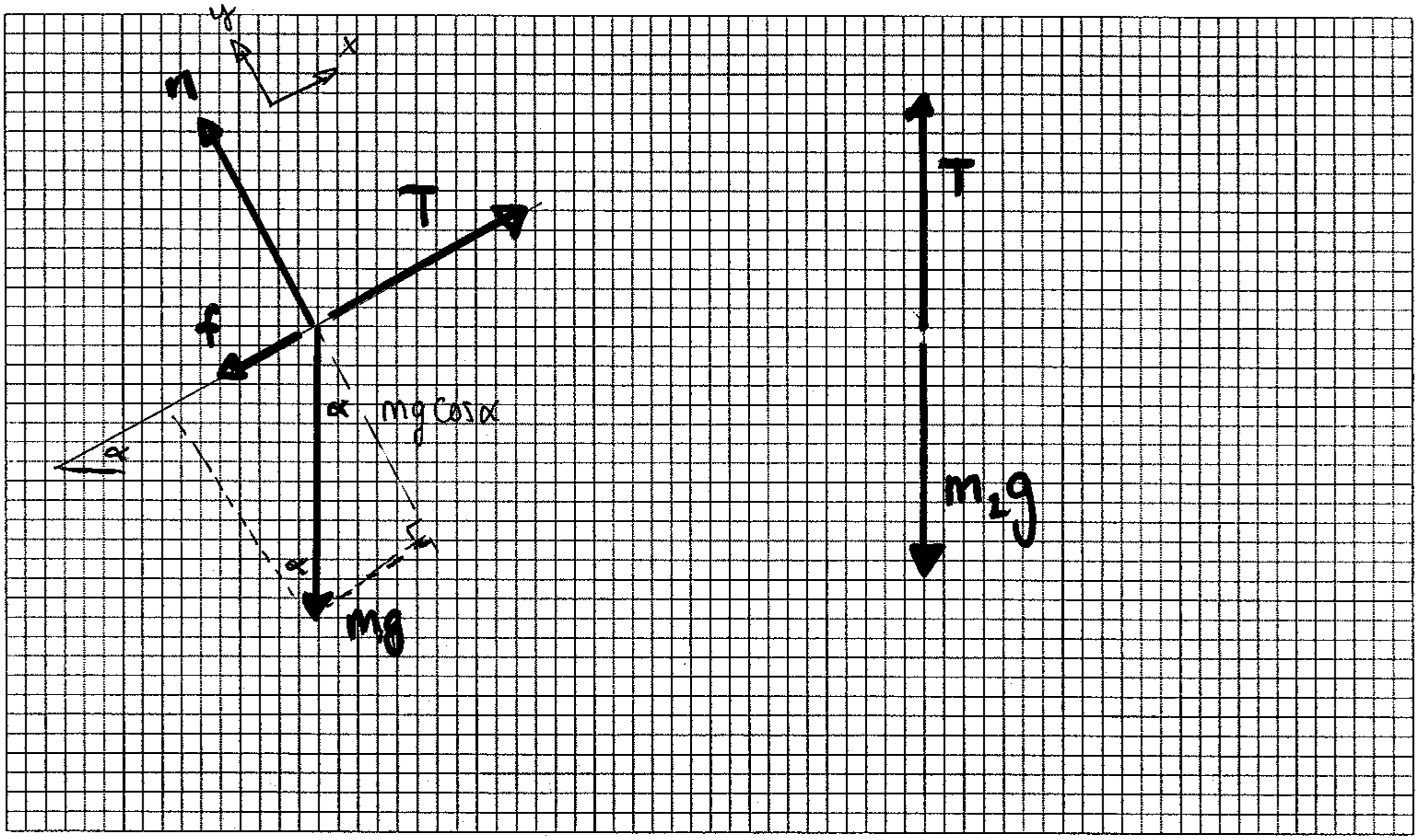
Note: horizontal forces may be LARGER, but not SMALLER, than shown here.

Calculations. 28pt each. Draw free body diagrams when appropriate.

1. Consider two blocks connected by a massless string over a pulley, as shown. If the coefficient of static friction with the slope is 1, what is the largest mass m_2 that can hang without slipping? Express your answer in terms of m_1, α (and g if you need it).



$a = 0$



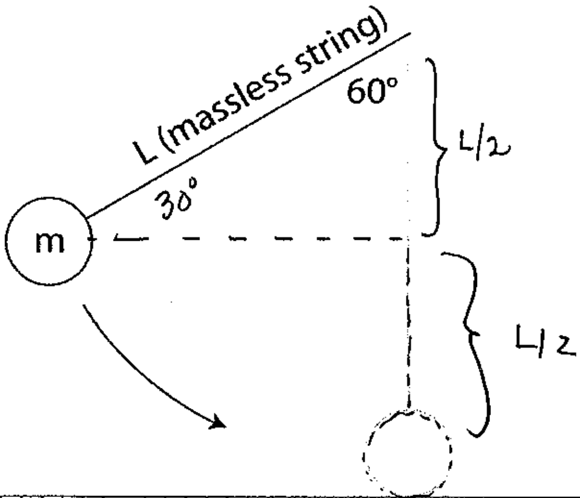
$\sum F_y = 0 \quad n - m_1 g\cos\alpha = 0 \quad n = m_1 g\cos\alpha \qquad T = m_2 g.$

$\sum F_x = 0 \quad T - f - m_1 g\sin\alpha = 0$

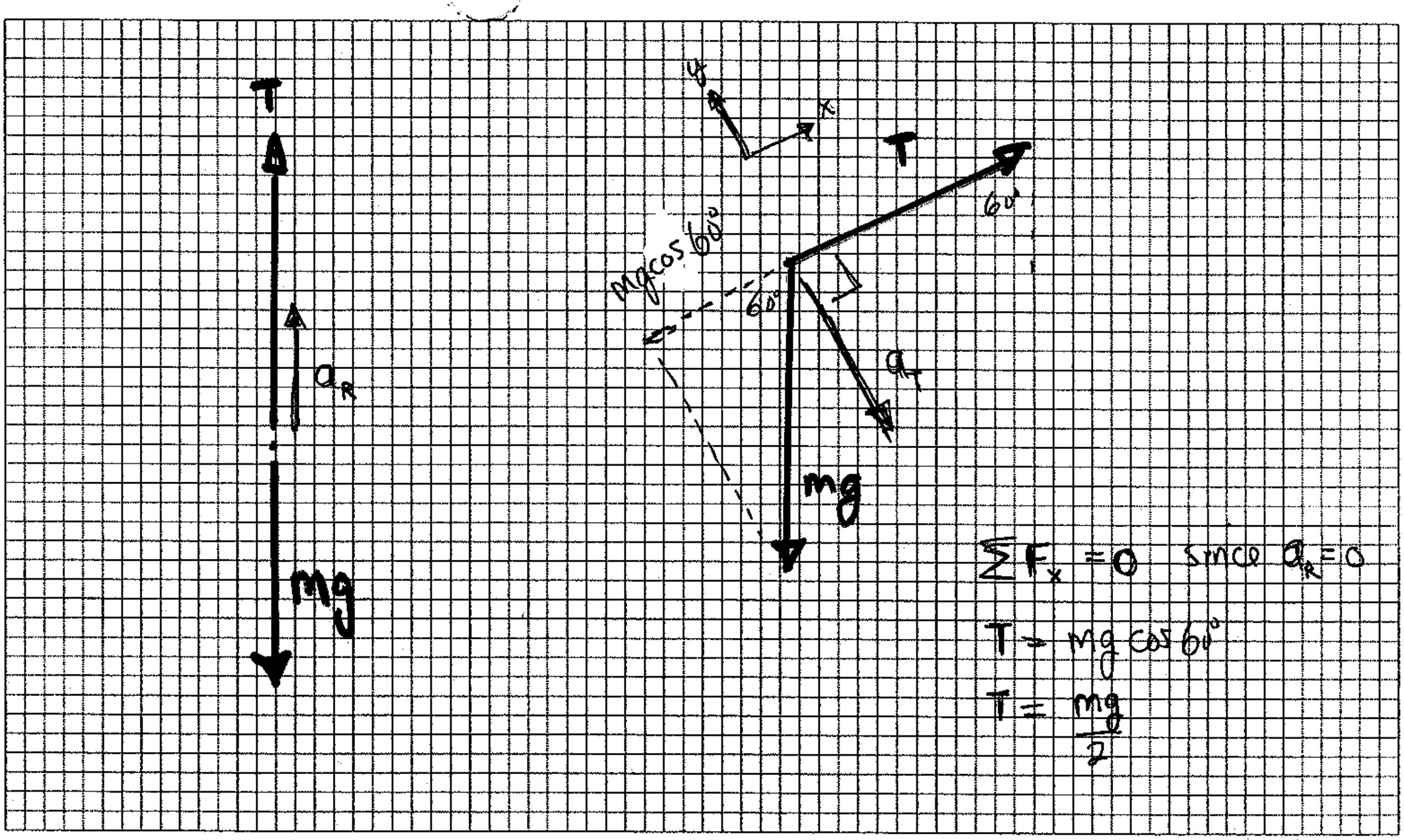
$f \le \mu n = m_1 g\cos\alpha \quad$ so $\quad m_2 g - m_1 g\cos\alpha - m_1 g\sin\alpha = 0$

Max $\quad m_2 = m_1(\cos\alpha + \sin\alpha)$

2. A pendulum bob, mass m, is released from a 60° angle. Find the tension in the (massless) string when the bob is at the bottom, and when it reaches 60°. Express your answer in terms of m, g, and length of the pendulum, L (if you need it.)



$\sin 30° = \frac{1}{2}$



$T - mg = ma_R = \frac{mv^2}{L}$

V: energy cons.

$U_f - U_i + K_f - K_i = 0$

$0 - mg\frac{L}{2} + \frac{1}{2}mv^2 - 0 = 0$

$\frac{mv^2}{L} = mg$

$T - mg = mg$ $\boxed{T = 2mg}$

Short Answer 4pt each.

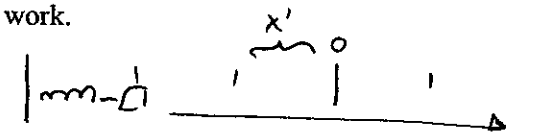
1. A constant force of $(\hat{\imath} - \hat{\jmath})$ N acts on a particle during a displacement of $-3\hat{\jmath}$ m. What is the work done by this force?

$$W = \vec{F} \cdot \vec{s} = (\hat{\imath} - \hat{\jmath}) \cdot (-3\hat{\jmath}) \text{ Nm} = 3 \text{ Nm.}$$

2. If the displacement takes 3 seconds, what is the *power* provided (or dissipated) by the force?

$$P = \frac{W}{t} = 1 \text{ W}$$

3. If a horizontal spring on a rough table is compressed a distance x' by a mass m, and then released, the mass returns to x=0 (stopping there). If the same spring is compressed 2x' by the same mass and then released, the mass will slide to what x coordinate? Show work.

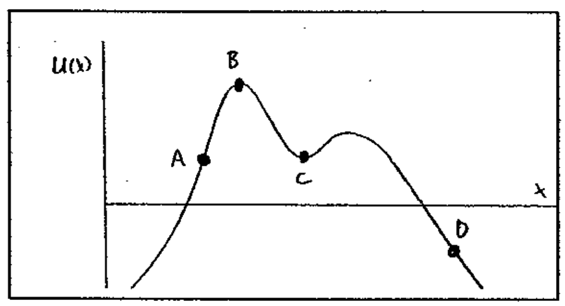


① $\frac{1}{2}kx'^2 = \mu mg x'$

② $\frac{1}{2}k(2x')^2 = \mu mg(2x' + x)$

Put ① into ② $4\mu mg x' = \mu mg(2x' + x)$ $x = 2x'$ Distance past x=0.

4. On the graph of potential energy, identify a **stable** equilibrium point. At which point is the force in the –x direction?



C stable.

A F is → –x.

5. Assume the frictional force on a car, when in a braking skid, is constant. If a car takes 50 feet to stop when going 30 mph, what will be its stopping distance when going 60 mph? (Assume a braking skid. Show work.)

$$F \cdot s = \Delta K = \frac{1}{2}mv^2$$

$$\Delta K_{60} = 4\Delta K_{30}$$

so

$$s_{60} = 4 s_{30}$$ since F is same. → 200 ft.

6. Bonus Question: Does a car stop more quickly with anti-lock brakes? If so, why?

Yes. $\mu_s > \mu_k$.