PHY 211 – Final (Version 1)

Name (please print): ______________________________

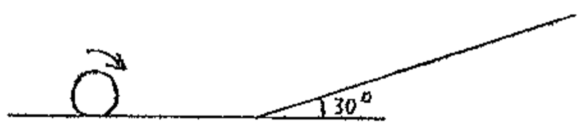
SUID: ____________

Please circle your TA's name: **Tyler** **Xingbo** **Zek**

It is very important that you print your name at the top of the exam page. Please do it before you read any questions!

Document your work. Use the back of each sheet if you run out of space.

1.[25 pts total] A hollow sphere of mass 0.2 kg rolls along a horizontal floor without slipping and then up a 30° incline. It is rolling along the horizontal surface with speed 3 m/s. (The moment of inertia of a hollow sphere about an axis through its center is $I = 2/3\ m\ r^2$.)



a. [5 pts] What is the total kinetic energy of the sphere when it is rolling along the horizontal surface?

b. [6 pts] How far up the ramp does the sphere go before starting to roll back down?

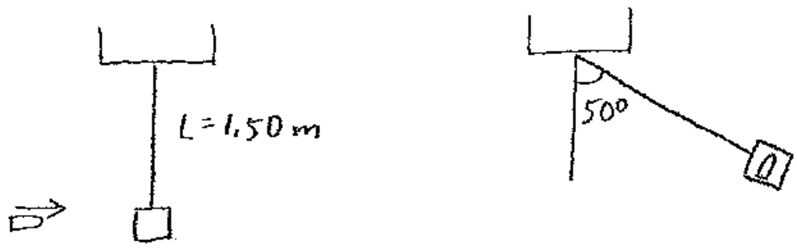
c. [4 pts] If we doubled the radius of the ball, how would the distance that the sphere goes up the ramp change? Explain.

d. [3 pts] Now the ramp and floor are greased so that we can ignore friction. A block of mass 0.2 kg slides along the horizontal surface with the same initial speed as the sphere, 3 m/s. What is the total kinetic energy of the block as it slides along the horizontal surface?

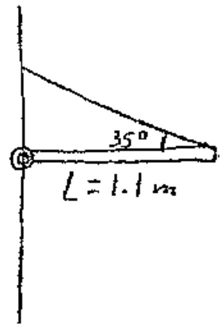
e. [4 pts] How far up the ramp does the block go?

f. [3 pts] Which goes higher up the ramp, the sphere or the block? Explain.

2. [25 pts total] A 12 g bullet is fired into a 1400 g wood block that is hanging from a string of length 1.50 m. The bullet embeds itself into the block, and the block swings out to an angle of 50°. What was the speed of the bullet?



3. [25 pts total] A 3.0 kg rod of length 1.1 m is attached to a pivot and held in place by a rope attached to one of its ends as shown in the diagram. The angle between the rod and the rope is 35°.



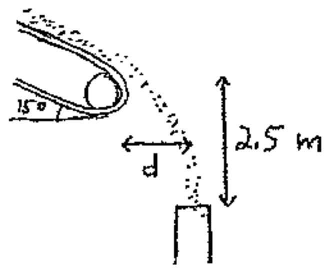
a. [3pts] Draw the extended free-body diagram for the rod.

b. [4pts] What is the tension in the rope?

c. [6pts] What are the x and y components of the force acting at the hinge?

d. [6pts] The rope breaks. At that instant, what is the instantaneous angular acceleration of the rod about the pivot? (The moment of inertia of a thin rod about its center is $1/12\ m L^2$. The moment of inertia of a thin rod about its end is $1/3\ m L^2$.)

4. [25 pts total] Sand moves without slipping at 5.0 m/s down a conveyer that is tilted at 15°. The sand enters a pipe that is 2.5 m below the end of the conveyer belt, as shown in the figure.



a. [5 pts] What is the speed of the sand as it enters the pipe?

b. [10 pts] What is the horizontal distance between the conveyer belt and the pipe?

c. [10 pts] What is the horizontal distance if we assume that the conveyer belt is not on Earth but on Mars? (Mass of Mars=6.42×10^{23} kg, mean radius of Mars=3.37×10^{6} m, Mean distance between Mars and sun=2.28×10^{11} m.)
$G = 6.67 \times 10^{-11}\ N\ m^2/kg^2$

Formula Sheet for Physics 211

$$\vec{v} = \frac{d\vec{x}}{dt}; \quad \vec{a} = \frac{d\vec{v}}{dt}$$

$$\Delta x = x(t_2) - x(t_1) = \text{ signed area under the v(t) curve from t1 to t2} = \int_{t_1}^{t_2} v(t)dt$$

$$\Delta v = v(t_2) - v(t_1) = \text{ signed area under the a(t) curve from t1 to t2} = \int_{t_1}^{t_2} a(t)dt$$

$$v_x = v_{0x} + a_x t; \quad x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2; \quad v_x^2 = v_{0x}^2 + 2a_x \Delta x$$

$$\theta = \frac{s}{r} : \theta \text{ in radians}; \quad \omega = \frac{d\theta}{dt} \quad \alpha = \frac{d\omega}{dt}$$

$$a_c = a_{rad} = \frac{v^2}{r}; \quad T = \frac{2\pi r}{v}$$

$$v = \omega r : \omega \text{ in radians per unit time}; \quad a_{tan} = \alpha r : \alpha \text{ in radians per unit time squared}$$

$$\omega = \omega_0 + \alpha t; \quad \theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2; \quad \omega^2 = \omega_0^2 + 2\alpha\Delta\theta$$

$$\vec{v} = v_x\hat{i} + v_y\hat{j}; \quad v_x = |v|\cos(\theta); \quad v_y = |v|\sin(\theta)$$

$$v = |\vec{v}| = \sqrt{v_x^2 + v_y^2}; \quad \theta = \tan^{-1}(v_y/v_x)$$

$$\vec{v}_{CB} = \vec{v}_{CA} + \vec{v}_{AB}$$

$$g = 9.8\ m/s^2$$

$$\vec{F}_{net} = \sum_i \vec{F}_i = m\vec{a}; \quad \vec{F}_{AB} = -\vec{F}_{BA}$$

$$|\vec{F}_{fk}| = \mu_k N; \quad |\vec{F}_{fs}| \le \mu_s N$$

$$\vec{I}_{net} = \vec{F}_{net}\Delta t = \text{ area under the F(t) curve from t1 to t2 } = \int_{t1}^{t2} F(t)dt$$

$$|F_{net,radial}| = \frac{mv^2}{R}$$

$$\vec{p} = m\vec{v}; \quad \vec{I} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$$

$$\vec{p}_f = \vec{p}_i \ \text{ (for an isolated system)}$$

$$E_{sys} = U + K = \text{constant for an isolated system}$$

$$K = \frac{1}{2}mv^2$$

$$U_g = mgh; \quad U_s = \frac{1}{2}k(x - x_0)^2$$

[redacted]

$$W = \vec{F} \cdot \vec{d} = Fd\cos\theta = \text{area under F(x) curve from x1 to x2} = \int_{x_1}^{x_2} F_x dx$$

$$F = -dU/dx \quad \Delta W = -\Delta U \text{ (for a conservative system)}$$

$$\Delta K = W_{net}; \quad \Delta E_{sys} = \Delta K + \Delta U + \Delta E_{th} = W_{ext}$$

$$P = \Delta W/\Delta t = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$$

$$\vec{r}_{CM} = \frac{\sum_i m_i r_i}{\sum_i m_i}$$

$$\vec{\tau} = \vec{r} \times \vec{F} \quad |\vec{\tau}| = rF\sin\theta$$

$$\tau_{net} = I\alpha, \alpha \text{ in radians per unit time squared}$$

$$I = \sum_i m_i r_i^2 = \int r^2 dm$$

$$\vec{F}_{net} = 0 \text{ and } \vec{\tau}_{net} = 0 \text{ in rigid-body equilibrium}$$

Table 9.2 Moments of Inertia of Various Bodies