UC – Irvine
Physics 3A
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Version: A

Final Examination

The exam is closed book, closed notes, open mind. You may use one of the allowed calculators. There are 5 problems, each worth 15 points. **Silence your cellular phones now**. This is an examination so the work you turn in must be your own. You must ***show all work*** to get full credit.

FOR ADMINISTRATIVE USE ONLY

DO NOT OPEN THE TEST UNTIL YOU ARE INSTRUCTED TO DO SO

Problem 1	
Problem 2	
Problem 3	
Problem 4	
Problem 5	
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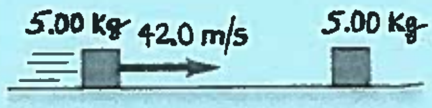
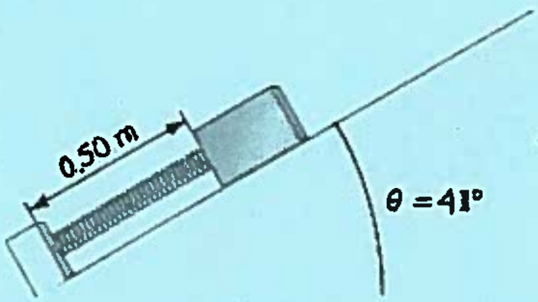
Problem 1. (15 points)
A 5.00-kg block moving at 42.0 m/s to the right on a horizontal, frictionless table collides head-on with a 5.00-kg block that is initially at rest. Determine the final velocities (magnitudes and directions) of the two blocks if the collision is ***elastic***.



Problem 2. (15 points)
A spring (k = 75.0 N/m) has a natural length of 1.00 m. The spring is compressed to a length of 0.500 m and a block of mass 1.50 kg is attached at its free end on a frictionless slope which makes an angle of 41.0° with respect to the horizontal as shown in the figure below. The spring is then released from rest. *How far* up the slope from the starting position will the block move up the incline before coming to rest?



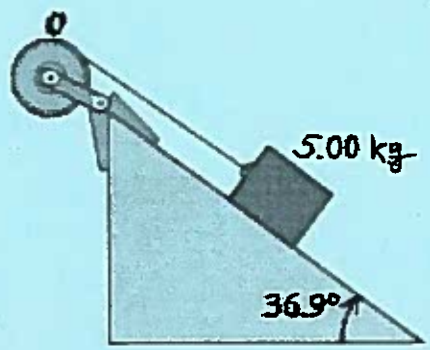
Problem 3. (15 points)
A 600-kg meteor is falling vertically downward and has a speed of 100 m/s when it is at a height of 900 km above the surface of the Earth. Ignore air resistance. The meteor strikes a bed of sand in which it is brought to rest in a distance of 3.90 m. The radius of the Earth is 6378 km and the mass of the Earth is 5.98×10^{24} kg.

(a) What is the speed of the meteor just before it strikes the sand?

(b) What is the *average force* (magnitude and direction) exerted by the meteorite *on the sand*?

Problem 4. (15 points)
A block with mass 5.00 kg slides down a surface inclined 36.9° to the horizontal as shown in the figure below. The coefficient of kinetic friction between the block and the inclined surface is 0.150. A string attached to the block is wrapped around a flywheel and the flywheel rotates about a fixed axis at point *O*. The flywheel has mass 15.0 kg and moment of inertia 0.500 kg m^2 with respect to the axis of rotation. The string pulls without slipping on the flywheel at a perpendicular distance of 0.150 m from the axis of rotation, i.e., the radius of the flywheel is 0.150 m.

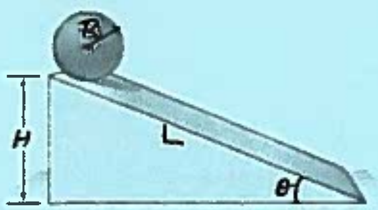
(a) What is the magnitude of the acceleration of the block down the inclined plane?



(b) What is the tension in the string?

Problem 5. (15 points)
A *solid cylinder* of radius R = 20.5 cm and mass M = 1.50 kg starts from *rest* and *rolls without slipping* down a $\theta = 30.0^{\circ}$ incline that is L = 10.0 m long. The moment of inertia of a solid sphere about an axis through its center is given by $I = (1/2)MR^2$.

(a) What is the ***speed of the center of mass*** of the solid cylinder when it reaches the bottom of the incline?



(b) What is the ***frictional force*** acting on the solid cylinder as it rolls down without slipping on the incline?

Formula Sheet

Some useful constants:

$g = 9.80\ m/s^2 = 980\ cm/s^2 = 32.0\ ft/s^2$

$G = 6.67x10^{-11}\ N\ m^2/kg^2$

Useful formulas:

$\bar{r}_f - \bar{r}_0 = \bar{v}_0 t + \frac{1}{2}\bar{a}\,t^2$ $\quad \vec{v}_f = \vec{v}_0 + \vec{a}\,t$ $\quad \vec{v}_f^{\,2} = \vec{v}_0^{\,2} + 2\vec{a}\cdot(\vec{r}_f - \vec{r}_0)$

<u>Uniform Circular Motion:</u> $2\pi r = vT$

$\vec{p} = m\vec{v}$ $\quad I = \sum_i m_i r_i^2$ $\quad \vec{\tau} = \vec{r}\times\vec{F}$ $\quad \Sigma\vec{F} = m\,\vec{a}$

$\sum\vec{\tau} = I\vec{\alpha}$ $\quad v = r\omega$ $\quad a_t = r\alpha$ $\quad a_c = \frac{v^2}{r} = \omega^2 r$

$\overrightarrow{V_{Bf}} - \overrightarrow{V_{Af}} = -(\overrightarrow{V_{Bo}} - \overrightarrow{V_{Ao}})$

$\bar{v}_{ave} = \frac{\Delta\bar{r}}{\Delta t}$ $\quad \bar{v} = \frac{d\bar{r}}{dt}$ $\quad \bar{a}_{ave} = \frac{\Delta\bar{v}}{\Delta t}$ $\quad \bar{a} = \frac{d\bar{v}}{dt} = \frac{d^2\bar{r}}{dt^2}$

$f_k = \mu_k n$ $\quad f_s \le \mu_s n$

$F_s = -k\,x$ $\quad KE_{translation} = \frac{1}{2}mv^2$ $\quad KE_{rotation} = \frac{1}{2}I\omega^2$

$U_s = \frac{1}{2}kx^2$

$U_{grav} = mgh$ or $U_{grav} = -\frac{GMm}{r}$ $\quad \Sigma W_{all\ forces} = \Delta(KE)$

$\Sigma W_{nc} = \Delta(KE) + \Delta(U_{grav}) + \Delta(U_s)$ $\quad E_{mechanical} \equiv KE + U$

$E_o + \Sigma W_{nc} = E_f$

$W_{grav} = -\Delta(U_{grav})$ $\quad W_{spring} = -\Delta(U_{spring})$

$W_F = \bar{F}\bullet(\Delta\bar{r}) = F(\Delta r)\cos(\theta)$