Exam-II Solutions (Fall '11)

1.) *Multiple Choice* *(18 pts.)*

For each statement below, circle the correct answer (TRUE or FALSE, no reasoning required).

(a) In satellite motion, the gravitational force acts as a centripetal force.
[✓ TRUE] FALSE

(b) If a box is sliding (and slowing down) on a rough horizontal surface, the normal force on the box is doing negative work.
TRUE [✓ FALSE]

(c) A static(!) friction force does not do work.
TRUE [✓ FALSE]

(d) Work is a vector quantity.
TRUE [✓ FALSE]

(e) If a force on the same object can have different values at the same point, that force is non-conservative.
[✓ TRUE] FALSE

(f) If the same impulse is applied to two objects with different mass moving at the same velocity, the final velocity of the two objects will be different.
[✓ TRUE] FALSE

No.	Points
1	HZ
2	P.K
3	CB
4	RR
5	TG
Sum	

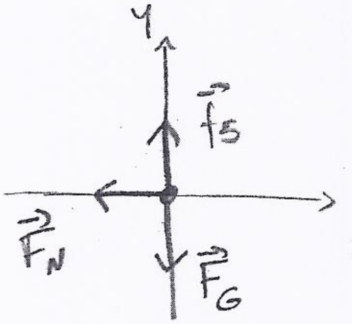
2.) *Circular Motion* (*20 pts.*)

At an amusement park, kids stand on the floor against the inner wall of a hollow vertical cylinder with radius $3.5\,m$. When the cylinder rotates with a period of 1.8 s, the floor of the cylinder is dropped but the kids remain pinned to the wall.

(a) Draw a free-body force diagram for one kid.

(b) Calculate the minimum static friction coefficient between the kids and the wall for the kids not to slide down.

(a)



(b) y-dir $0 = f_s - F_G = \mu_s F_N - mg \Rightarrow F_N = \frac{mg}{\mu_s}$

x-dir $F_c = F_N = \frac{mg}{\mu_s}$

$$\frac{mv^2}{r} = \frac{mg}{\mu_s} \Rightarrow \mu_s = \frac{gr}{v^2}$$

$$v = \frac{2\pi r}{T}$$

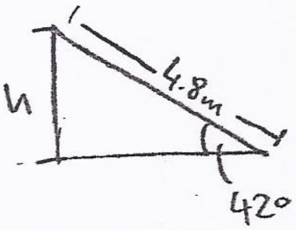
$$\Rightarrow \boxed{\mu_s = \frac{grT^2}{4\pi^2 r^2} = \frac{gT^2}{4\pi^2 r} = 0.23}$$

3.) *Non/Conservative Work and Kinetic Energy* (20 pts.)

A roof worker nudges his tool box (mass 5.0kg) so that it starts sliding (starting from rest) down along a roof which is inclined at an angle of 42° above the horizontal. After sliding a distance of 4.8m, the box reaches the edge of the roof.

(a) Calculate the speed of the box at the edge of the roof assuming there is no friction while sliding.

(b) Calculate the speed of the box at the edge of the roof assuming the presence of a kinetic friction force of 19N while sliding.



(a) $E_i = E_f$

$mgh = \frac{1}{2}mv_f^2$, $h = d\sin\theta$

$\Rightarrow \boxed{v_f = \sqrt{2gd\sin\theta}} = \boxed{7.93\ \frac{m}{s}}$

(b) $W_{nc} = \Delta E$

$E_i + W_{nc} = E_f$ $W_{nc} = f_k\, d\cos\phi$

$mgh - f_k d = \frac{1}{2}mv_f^2$ $= -f_k d$

$\Rightarrow \boxed{v_f = \sqrt{2gh - 2\frac{f_k}{m}d}} = \boxed{5.15\ \frac{m}{s}}$

4.) *Spring Recoil* (8+13 pts.)

A cart of mass $m_1 = 60\,kg$ and another cart of mass $m_2 = 20\,\text{kg}$ are pressed against each other, compressing a massless spring in between them by $12\,cm$. The spring constant is $820\,N/m$. The system is then released from rest and the two masses recede from each other leaving the relaxed spring behind. Neglect friction.

(a) Use momentum conservation to express the final velocity v_{1f} in terms of v_{2f}.

(b) Use conservation of mechanical energy to calculate the two final velocities.

(a) $$P_i = P_f$$

$$0 = m_1 V_{1f} + m_2 V_{2f}$$

$$\Rightarrow \quad V_{1f} = -\frac{m_2}{m_1} V_{2f} = -\frac{1}{3} V_{2f}$$

(b) $$E_i = E_f$$

$$\frac{1}{2}kx^2 = \frac{1}{2}m_1 V_{1f}^2 + \frac{1}{2}m_2 V_{2f}^2$$

$$= \frac{1}{2}m_1\left(-\frac{m_2}{m_1}V_{2f}\right)^2 + \frac{1}{2}m_2 V_{2f}^2 = \frac{1}{2}m_2 V_{2f}^2\left(1+\frac{m_2}{m_1}\right)$$

$$\Rightarrow \quad \boxed{V_{2f} = \left(\frac{kx^2}{m_2\left(1+\frac{m_2}{m_1}\right)}\right)^{1/2}} = \boxed{0.665\ \frac{m}{s}}$$

$$\boxed{V_{1f} = -\frac{1}{3}V_{2f}} = \boxed{-0.222\ \frac{m}{s}}$$

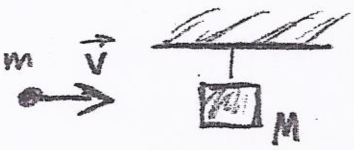
5.) *Ballistic Pendulum* (*21 pts.*)

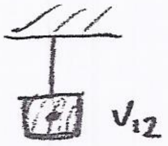
A bullet of mass $12g$ with unknown horizontal velocity is fired at a block of wood (mass $3.3kg$) which is initially hanging at rest, suspended from the ceiling as a pendulum. The bullet gets stuck in the block and both swing up to a height of $22\,cm$ above the starting position.

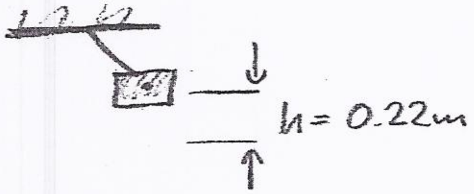
(a) What is the velocity of the block+bullet right after the collision?

(b) What is the initial velocity of the bullet before hitting the block?

(c) How much energy (non-conservative work) has been dissipated in the collision of block and bullet?







(a)

$$E_i = E_f$$

$$\frac{1}{2}(m+M)\,v_{12}^2 = (m+M)\,gh \Rightarrow \boxed{V_{12} = \sqrt{2gh}} = 2.0765\,\frac{m}{s}$$

(b)

$$P_i = P_f$$

$$mv = (m+M)\,V_{12}$$

$$\boxed{V = \frac{(m+M)}{m}\,V_{12} = 573\,\frac{m}{s}}$$

(c)

$$\boxed{W_{nc} = \Delta E}$$

$$= E_f - E_i = \frac{1}{2}(m+M)\,v_{12}^2 - \frac{1}{2}mv^2$$

$$= 7 - 1971 = \boxed{-1964\,J}$$