Exam-2 Solutions (Spring 2014)

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

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

(a) When you take a (safe) turn with your car, the static friction force between tires and road provides the necessary centripetal force.
TRUE FALSE

(b) When a box is sliding on a horizontal rough surface, the normal force on the box does not do any work on the box.
TRUE FALSE

(c) If an object doubles its speed, its kinetic energy triples.
TRUE FALSE

(d) If negative net work is done on an object, the object is slowing down.
TRUE FALSE

(e) When a person climbs a mountain to its top, the work done by gravity on the person depends on the path taken to the top.
TRUE FALSE

(f) When two objects collide and stick together thereafter, momentum is conserved in that collision.
TRUE FALSE

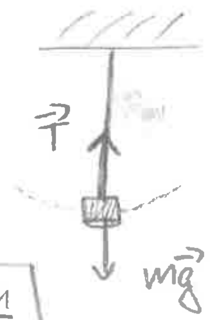
No.	Points
1	YZ
2	BY
3	IS
4	RR
5	AL
Sum	

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

A freight box of mass 42 kg is attached to the end of a massless 3 m long cable which is suspended from the ceiling of a storage hall. A worker passes by and gives the box a nudge to make it swing, reaching a maximal speed of 5 mph. ($1\,m/s = 2.25\,mph$)

(a) At which point in the swinging motion does the box reach the maximal speed, and what is its net acceleration at this point?

(b) What is the maximal tension in the cable?



(a) At the bottom:

$$\sum \vec{F} = m\vec{a}_c$$

$$\boxed{a_c = \frac{v^2}{R}} = \frac{(5/2.25)^2}{3} = \boxed{1.65\ \frac{m}{s^2}}$$

(b) $$T - mg = m a_c$$

$$\Rightarrow \boxed{T} = mg + m a_c = \boxed{481\ N}$$

3.) *Gravity* (*20 pts.*)

An explorer team lands on a thus far uncharted planet. The planet's circumference is determined as 34500 mi, and a free fall experiment on the surface shows objects to fall through 3 m in 0.7 s (starting from rest). (1 mi=1609 m)

(a) Determine the gravitational acceleration on the planet's surface.

(b) Determine the mass of the planet and express it in units of Earth's mass, $M_E = 5.97 \cdot 10^{24} kg$.

(a) $y = y_0 - \frac{1}{2} \tilde{g} t^2$ $\quad y = 0$, $y_0 = 3m$

$$\Rightarrow \boxed{\tilde{g} = \frac{2y_0}{t^2} = 12.2 \frac{m}{s^2}}$$

(b) $m\tilde{g} = G_N \frac{m M_P}{R_P^2}$

$$\tilde{g} = G_N \frac{M_P}{R_P^2} \Rightarrow M_P = \frac{R_P^2 \tilde{g}}{G_N}, \quad C = 2\pi R_P$$

$$\Rightarrow \boxed{M_P} = \frac{(c/2\pi)^2 \tilde{g}}{G_N} = 1.43 \cdot 10^{25} kg$$

$$\boxed{= 2.4 \, M_E}$$

4.) *Non/Conservative Work* (8+10+4 pts.)

A kid on a sleigh is sliding on a frictionless horizontal snow surface at a speed of 16 mph. They then slide down a frictionless incline of height 5.5 m and afterwards encounter a rough horizontal ice patch of length 7.0m with a kinetic friction coefficient of 0.35 with the sleigh. (1m/s=2.25mph)

(a) What is the speed of the sleigh at the bottom of the hill, before reaching the ice patch?

(b) What is the speed of the sleigh after crossing the ice patch?

(c) If the mass of sleigh+kid is 49kg, how much non-conservative work has been done on them by the ice patch?

(a) $E_{top} = E_{bot}$ conservative

$$\frac{1}{2} m v_i^2 + mgh = \frac{1}{2} m v_f^2$$

$$\Rightarrow \boxed{v_f = (v_i^2 + 2gh)^{1/2}} = \boxed{12.6 \frac{m}{s}}$$

(b) $W_{nc} = \Delta E = \Delta K = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$

$$W_{nc} = -f_k s = -\mu_k mgs$$

$$\Rightarrow -\mu_k mgs = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$\Rightarrow \boxed{v_f = \sqrt{v_i^2 - 2\mu_k gs}} = \boxed{10.5 \text{ m/s}}$$

(c) $\boxed{W_{nc} = -\mu_k mgs} = \boxed{-1176 J}$

5.) *Inelastic Collision* (20 *pts.*)

A bullett of mass $8.5g$ and horizontal velocity $630m/s$ is fired into a block of wood (mass $2.8kg$) which is initially at rest on a horizontal frictionless surface. The bullett penetrates the block and emerges with a horizontal velocity of $195m/s$ (neglect the effect of gravity on the bullett).

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

(b) How much energy has been dissipated due to the deformation in the block?

(a) $\underline{P}_i = \underline{P}_f$

$$m V_{1i} = m V_{1f} + M V_{2f}$$

$$\Rightarrow \boxed{V_{2f} = m\left(V_{1i} - V_{1f}\right)/M} = \boxed{1.32 \ m/s}$$

(b) $$W_{nc} = \Delta E = \Delta K = -\frac{1}{2} m v_{1i}^2 + \frac{1}{2} m v_{1f}^2 + \frac{1}{2} M v_{2f}^2$$

$$\boxed{W_{nc} = -1523 \ J}$$