Exam-I (Fall '07) - Solutions

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

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

(a) The distance traveled by a car on a trip can be much larger than the magnitude of the displacement for that same trip.
TRUE FALSE

(b) In projectile motion, the acceleration at the highest point of the trajectory is zero.
TRUE FALSE

(c) If an objects performs uniform circular motion, its speed is constant but its acceleration is not zero.
TRUE FALSE

(d) The magnitude of the static friction force on an object can range from f_s=0 to f_s=$\mu_s F_N$ (F_N: normal force).
TRUE FALSE

(e) If an object is resting on an inclined (rough) surface, the magnitude of the normal force must equal the magnitude of the weight force.
TRUE FALSE

(f) If an object is moving at constant velocity, there is no net force acting on that object.
TRUE FALSE

No.	Points
1	KK
2	RR
3	SR
4	DX
5	DX
6	TS
Sum	

2.) *1-D Motion* *(21 pts.)*

A car starts from rest at constant acceleration (the car can accelerate from 0 to 60mph in 8.5s). [10s] At the instant it starts, a truck passes by traveling at a constant speed of 25mph. (1m/s=2.25mph)

(a) What is the acceleration of the car?

(b) How far beyond it's starting point does the car catch up with the truck?

(c) How fast is the car moving when it catches up with the truck?

(a) $v_c = a_c t$ $\quad \boxed{a_c = \frac{v_c}{t} = \frac{60/2.25}{8.5} = 3.14 \frac{m}{s^2}}$ $[2.54 \frac{m}{s^2}]$

(b) $x_T = x_c$

$v_{To} t = \frac{1}{2} a_c t^2 \Rightarrow t = \frac{2 v_{To}}{a_c} = 7.08s$ $[8.75s]$

$\Rightarrow \boxed{x = v_{To} t = 78.7m}$ $[97.2m]$

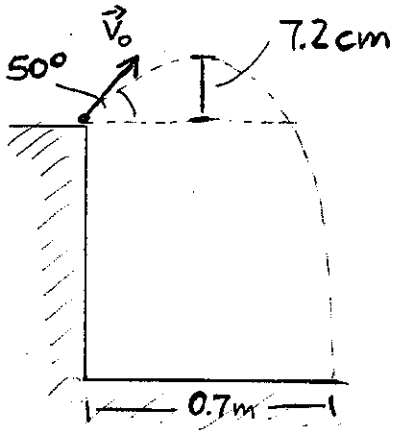
(c) $\boxed{v_c = a_c t = 22.2 \frac{m}{s}}$

3.) *Projectile Motion* *(16 pts.)*

A grasshopper leaps into the air from the edge of a vertical cliff. It's initial velocity is at an angle of 50° above the horizontal. It reaches a maximal height of $7.2cm$ above the launch point, and lands at the bottom of the cliff at horizontal distance of $0.7m$ from the cliff, see the sketch below. Neglect air drag. [5.8]

(a) What is the initial speed of the grasshopper?

(b) What is the height of the cliff?



(a)

$$v_y^2 = v_{oy}^2 - 2g(y - y_o) \quad = 0$$

$$\Rightarrow v_{oy} = \sqrt{2gy} = 1.19 \text{ m/s} \quad [1.07 \tfrac{m}{s}]$$

$$\boxed{v_o = \frac{v_{oy}}{\sin\theta_o} = 1.55 \tfrac{m}{s}} \quad [1.39 \tfrac{m}{s}]$$

(b) $x = v_{ox} t = v_o \cos(\theta_o)\, t$

$$\Rightarrow t = \frac{x}{v_o \cos\theta_o} = 0.7\,s \quad [0.78\,s]$$

$$\boxed{y = y_o + v_{oy} t - \tfrac{1}{2} g t^2 = -1.58\,m} \quad [-2.15m]$$

4.) *Relative Motion* [1.1] *(18 pts.)*

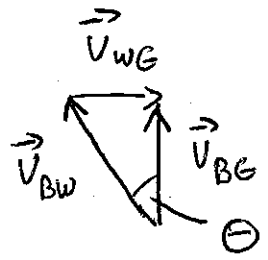
A river, $350m$ wide, is flowing due east with a speed of $1.5m/s$. The captain of a motor ferry wants to cross the river due north. The ferry has a still water speed of $3.5m/s$.

(a) Draw a sketch indicating all velocity vectors.

(b) At what angle (relative due north) should the captain steer the boat?

(c) How long does it take the boat to cross the river?

(a)



(b) $\vec{V}_{BG} = \vec{V}_{BW} + \vec{V}_{WG}$

$$\sin\theta = \frac{V_{WG}}{V_{BW}} = \frac{1.5}{3.5}$$

$$\Rightarrow \boxed{\theta = \sin^{-1}\left(\frac{1.5}{3.5}\right) = 25.4^\circ} \quad [18.3^\circ]$$

(c) $V_{BG} = V_{BW}\cos\theta = 3.16\ \frac{m}{s}$ $\quad [3.32\ \frac{m}{s}]$

$$y = V_{BG}\,t \Rightarrow \boxed{t = \frac{y}{V_{BG}} = 111s} \quad [105s]$$

5.) *Newton's 2.Law and Apparent Weight* *(12 pts.)*

A person whose mass is $75kg$ steps into an elevator which has a scale implemented into it's floor. Start by drawing a free-body diagram for the person and find the magnitude and direction of the elevator's acceleration if the scale reading is

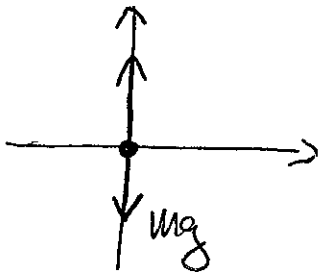
(a) $885N$.

(b) $555N$.

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

$$F_N - mg = ma$$

$$a = \frac{F_N - mg}{m}$$



(a) $F_N = 885N$

$$\Rightarrow \boxed{a = \frac{885 - 75*9.8}{75} = 2 m/s^2} \text{ upward}$$

$$[2.49 m/s^2]$$

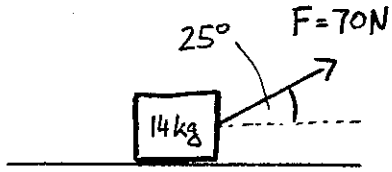
(b) $F_N = 555N$

$$\Rightarrow \boxed{a = \frac{555 - 75*9.8}{75} = -2.4 \frac{m}{s^2}} \text{ downward}$$

$$\left[-2.09 \frac{m}{s^2}\right]$$

6.) *Normal, Friction and Weight Forces* [65N] *(15 pts.)*

A person starts to pull on a box of mass $14kg$ with a force of $70N$ at an angle of 25° above the horizontal (see figure below). The box (which is initially at rest) is sitting on a horizontal surface, and the static friction coefficient between the surface and the box is 0.55.

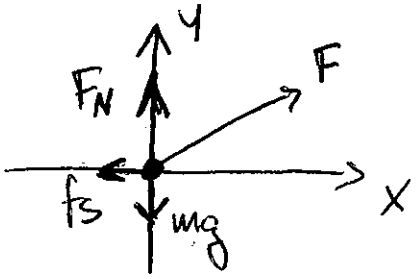


(a) Draw a free body diagram of the box.

(b) What is the normal force on the box?

(c) Will the box start moving (calculation required)?

(a)



(b) $\Sigma F_y = ma_y = 0$

$F_N + F\sin\theta - mg = 0$

$\Rightarrow \boxed{F_N = mg - f\sin\theta = 107.6\,N}$ [109.7N]

(c) $f_s^{max} = F_N \mu_s = -59.2N$ [60.35N]

$F_x = 70N\cos(25) = 63.4N > |f_s^{max}|$ yes, starts moving

[58.9N $< |f_s^{max}|$ no, does not move]