Exam I (S07) Solution Key

1.) *Multiple Choice* *(18 pts.)*
For each statement below, circle the correct answer (TRUE or FALSE, no reasoning required).

(a) When adding two vectors $\vec{A}$ and $\vec{B}$, the magitude of the resultant vector is equal to the sum of the magnitudes of $\vec{A}$ and $\vec{B}$.
TRUE FALSE

(b) In 1-D motion with constant (positive) acceleration, the velocity vs. time graph, $v(t)$, is a straight line.
TRUE FALSE

(c) The normal force on an object in contact with a horizontal surface is always equal in magnitude to its weight force.
TRUE FALSE

(d) If a driver takes a turn with his car, Newton's 2.law of motion implies that the driver experiences a centrifugal force.
TRUE FALSE

(e) If an object is in a uniform circular motion, the net acceleration of that object is zero.
TRUE FALSE

(f) Two books in a bookshelf attract each other by a small gravitational force.
TRUE FALSE

No.	Points
1	RR
2	Wei Ping
3	Lucas N.
4	Kevin Pesic
5	José V.
6	RR
Sum	

2.) *1-D Motion* (*18 pts.*)

At time $t_0 = 0s$, a block, inititally at rest, starts sliding down a plane with constant acceleration. During the time interval from $t_1 = 6s$ to $t_2 = 10s$ it moves a distance of $2m$. (3m)

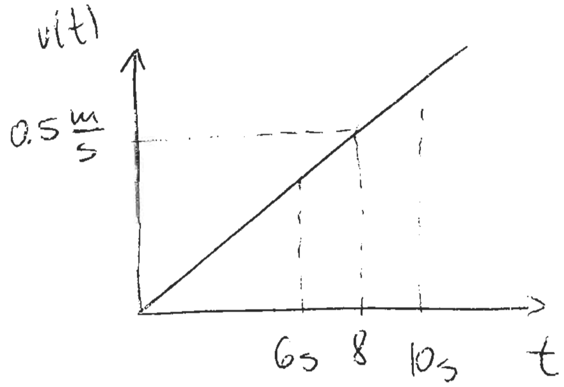
(a) What is the average **speed** of the block between t_1 and t_2?

(b) Sketch a graph of the blocks speed as a function of time, $v(t)$, for $t = 0 - 10s$. Indicate on the graph the speed at time $t = 8s$.

(c) What is the acceleration of the block?

(a) $\bar{V} = \frac{\Delta x}{\Delta t} = \frac{2}{4} = 0.5\ m/s$ [0.75 m/s]

(b)



(c) $a = \frac{\Delta v}{\Delta t} = \frac{0.5}{8} = 0.0625\ \frac{m}{s^2}$ [$0.09375\ \frac{m}{s^2}$]

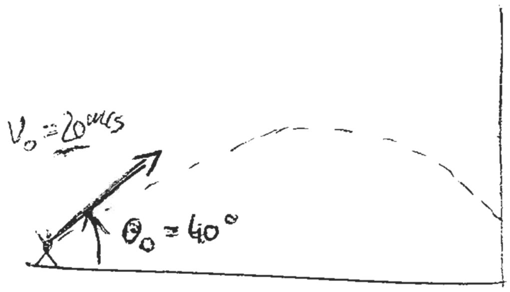
3.) *Projectile Motion* (*18 pts.*)

A kid throws a stone toward a tall (vertical) building-wall without windows. He launches the stone with initial speed $v_0 = 45mph$ at an angle of 40° above the horizontal, and records the time of impact at the wall at 2.4 s (2.2) after launch. ($1m/s = 2.25mph$)

(a) How far from the building is the the kid's position?

(b) At what height above the ground does the stone hit the building?

(c) What is the angle of the stones velocity relative to the horizontal immediately before hitting the wall?



(a) $x = V_{0x} t$ $\quad V_{0x} = V_0 \cos\theta_0 = 15.32$ m/s

$x = 36.8$ m $\quad$ [33.7 m]

(b) $y = V_{0y} t - \frac{1}{2} g t^2 = 2.63$ m , $\quad V_{0y} = V_0 \sin\theta_0 = 12.86$ m/s

[4.58 m]

(c) $V_x = V_{0x} = 15.32$ m/s

$V_y^2 = V_{0y}^2 - 2gy \Rightarrow V_y = \pm 10.66$ m/s $\quad V_y = -10.66 \frac{m}{s}$ at wall

[8.7 m/s]

$\tan\theta = \frac{V_y}{V_x}$

$\Rightarrow \theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) = -34.8°$ or 34.8° below horizontal

[−29.6°]

4.) *Newton's Law and Friction* (*18 pts.*)

A factory worker applies a horizontal force to a box which is initially at rest on a horizontal surface. When the force reaches $260N$ the box starts moving. The worker then maintains this force. The static friction coefficient between box and floor surface are $\mu_s = 0.35$. (0.4)

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

(b) What is the mass of the box?

(c) After the box starts moving, it reaches a speed of $1.5m/s$ after a distance of $2m$. What is the kinetic friction coefficient between box and floor surface?

(a)

(b) x-dir $\sum F_x = 0$ just before starts moving: $f = f_s^{max}$

$F_A - f_s^{max} = 0$ y-dir. $\sum F_y = 0$

$F_A - \mu_s F_N = F_A - \mu_s mg = 0$ $F_N - mg = 0 \Rightarrow F_N = mg$

$\Rightarrow \boxed{m = \frac{F_A}{\mu_s g} = 75.8\,kg}$ [66.3kg]

(c) $v_x^2 = v_{0x}^2 + 2ax = 2ax \Rightarrow a = \frac{v_x^2}{2x} = 0.5625\frac{m}{s^2}$

$\sum F_x = ma$

$F_A - f_k = ma$, $f_k = \mu_k F_N = \mu_k mg$

$\Rightarrow \boxed{\mu_k = \frac{F_A - ma}{mg} = 0.2913}$ [0.343]

5.) *Circular Motion and Tension* (18 pts.)

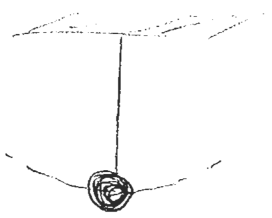
A bowling **ball** of mass $45kg$ is attached to the ceiling via a massless rope of length $2.5m$. The ball is pulled to the side and released, resulting in a swinging motion which describes the arc of a circle. As the ball swings through the lowest point, its speed is $3.2m/s$. (2.6 m/s)

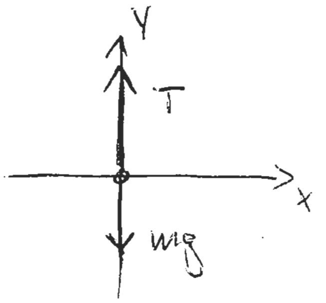
(a) Draw a free-body diagram for the ball at the lowest point.

(b) What is the net acceleration of the ball at the lowest point?

(c) What is the tension force in the rope at the lowest point?

(a)





(b) $a_c = \frac{v^2}{r} = 4.1 \, m/s^2$ [$2.7 \, m/s^2$]

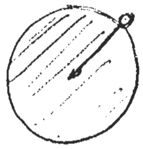
(c) $\Sigma F_y = F_c$

$T - mg = F_c$

$T = F_c + mg = 625N$ [562N]

6.) *Gravitation on the Moon* (10 pts.)

The Moon's mass and radius are $M_M = 7.35 \cdot 10^{22} kg$ and $R_M = 1740 km$. Use Newton's universal law of gravitation (as well as Newton's 2. Law of motion) to calculate the acceleration due to gravity, g_M, on the Moon's surface. What percentage of $g = 9.8\,m/s^2$ does this correspond to?



$$F_G = m g_M$$

$$G \frac{m M_M}{R_M^2} = g_M m$$

$$\Rightarrow \boxed{g_M = G \frac{M_M}{R_M^2} = 1.62 \frac{m}{s^2}}$$

$$\boxed{\frac{g_M}{g} = 16.5\%}$$