Solution Key - Exam-1

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

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

(a) If a projectile is thrown vertically upward, the time to return to the launch point is twice as long as the time to reach the maximal height.
TRUE FALSE

(b) In projectile motion, the acceleration at the highest point of the motion is not zero.
TRUE FALSE

(c) Since the speed in uniform circular motion is constant, the acceleration is zero.
TRUE FALSE

(d) If a person exerts a force on an object, that object exerts an equal-opposite force on the person.
TRUE FALSE

(e) The normal force on an object is always equal-opposite to its weight force.
TRUE FALSE

(f) The static friction force on an object acts in the same direction as the normal force on that object.
TRUE FALSE

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

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

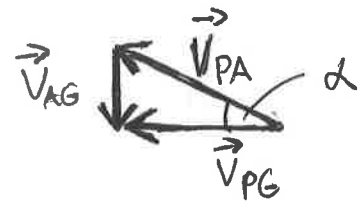
An airplane is scheduled to fly due west from Houston to San Antonio. However, a strong north wind is blowing at a speed of 50 *mph*. The cruising speed of the plane in still air is 350 *mph*.

(a) Draw a diagram of the how the velocities add up to the total.

(b) At what angle relative to west does the pilot have to aim the plane to make sure to fly straight west relative to the ground?

(a)

$$\vec{V}_{PG} = \vec{V}_{PA} + \vec{V}_{AG}$$



(b) $\sin\alpha = \frac{V_{AG}}{V_{PA}} = \frac{50}{350}$

$\rightarrow \boxed{\alpha = 8.21^\circ}$ of West

3.) *Projectile Motion* *(20 pts.)*

On an indoor court, a tennis player hits a ball with the rim of his racket, launching it at a speed of 45 mph and an angle of 60° above the horizontal. After 1.4 s, the ball hits the ceiling. ($1\,m/s = 2.25\,mph$)

(a) What is the speed of the ball when it hits the ceiling?

(b) How high above the launch point is the ceiling?

(a)

$V_0 = 45 mph$

$\theta_0 = 60°$

$V_y = V_{oy} - gt$

$V_{oy} = V_0 \sin\theta_0$

$V_{oy} = \frac{45}{2.25} \sin 60$

$V_{oy} = 17.32 \frac{m}{s}$

$V_y(t=1.4s) = V_{oy} - gt = 3.60 \frac{m}{s}$

$V_{ox} = V_0 \cos\theta_0 = 10 m/s = V_x$

$\Rightarrow V_f = \sqrt{V_x^2 + V_y^2} = 10.63 m/s$

(b) $y = y_0 + V_{oy} t - \frac{1}{2} g t^2$

$t = 1.4$

$y_0 = 0$

$V_{oy} = 17.32$

$\boxed{y_{ceiling} = 14.64 m}$

4.) *Tension Force* *(4+8+8 pts.)*

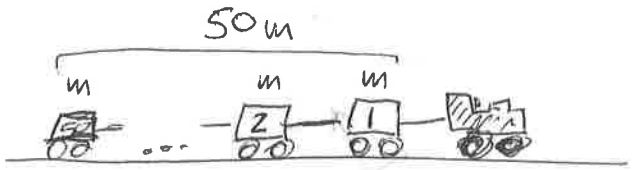
The 50 cars of a freight train are connected with cables which can safely withstand a tension of up to half of a car's weight force. Assume each car to have the same mass, which, however, is not known. Neglect friction. $(1\,m/s = 2.25\,mph)$

(a) If the train is accelerating, which of the 50 cables bears the maximum tension?

(b) How large is the maximal (safe) acceleration of the train?

(c) Under maximal acceleration, how much distance is required to reach a speed of $55\,mph$ when starting from rest?

(a)



maximal tension in first cable (between locomotive and car-1)

(b) $T_{max} = \frac{1}{2} m g$

$= (50\,m)\, a_{max}$ $\Rightarrow$ $\boxed{a_{max} = \frac{1}{100} g = 0.098 \frac{m}{s^2}}$

(c) $v^2 = v_0^2 + 2a\Delta x$

$v_0 = 0$

$v = 55/2.25 = 24.4\ m/s$

$\boxed{\Delta x = \frac{v^2}{2a_{max}} = 3050\,m}$

5.) *Inclined Plane with Friction* *(8+8+6 pts.)*

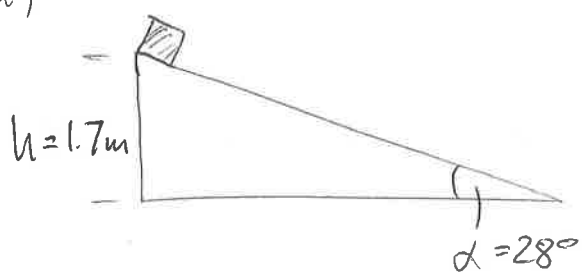
A box is released from rest, sliding down a plane inclined at an angle of 28° above the horizontal. The starting point of the box is at a vertical height of 1.7 m above ground level, and the kinetic friction coefficient between box and plane surface is 0.15.

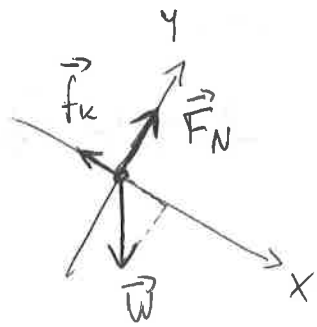
(a) Draw the free-body diagram of the box.

(b) Calculate the acceleration of the box.

(c) How long (in s) does it take the box to reach the ground level at the end of the plane?

(a)





(b) $m a_x = W_x - f_k$

$= mg \sin\alpha - \mu_k F_N$

$= mg \sin\alpha - \mu_k mg \cos\alpha$

$0 = m a_y = F_N - W_y$

$\Rightarrow F_N = W_y = mg \cos\alpha$

$\Rightarrow \boxed{a_x = g(\sin\alpha - \cos\alpha) = 3.3\ m/s^2}$

(c) $x = \frac{1}{2} a_x t^2$, $x = \frac{h}{\sin\alpha} = 3.62\,m$

$\Rightarrow \boxed{t = \sqrt{\frac{2x}{a_x}} = 1.48\ s}$