Exam-1 Solution Key (Sp 16)

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

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

(a) The stopping distance of a car doubles if the speed of the car doubles (assume a constant deceleration).
TRUE FALSE

(b) The magnitude of the centripetal acceleration in uniform circular motion is constant.
TRUE FALSE

(c) The velocity vector in uniform circular motion is constant.
TRUE FALSE

(d) The gravitational acceleration of a feather is equal to that of a metal block.
TRUE FALSE

(e) Newton's three laws of motion are valid in accelerating reference frames.
TRUE FALSE

(f) If a truck is accelerating horizontally in positive x-direction, a box which rests on its loading bed is accelerated by the static friction force between box and bed.
TRUE FALSE

No.	Points
1	CH
2	RR
3	TW
4	TW
5	YZ
Sum	

2.) *Free Fall* *(21 pts.)*

A construction worker on top of a buildng wonders how tall the building is. He drops a brick from rest and measures the time until impact on the ground to be 3.7 s (neglect air resistance).

(a) How tall is the building?

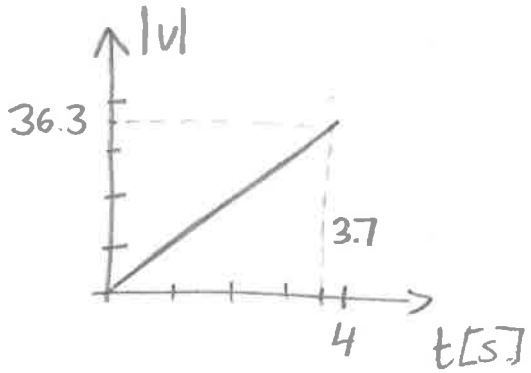
(b) How fast is the brick moving just before it hits the ground?

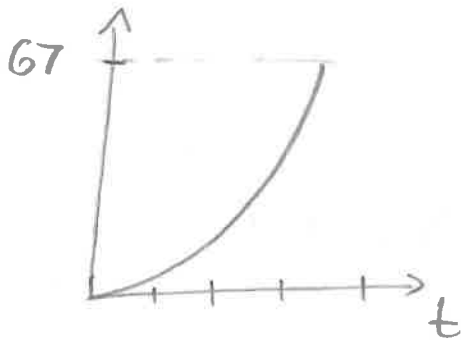
(c) Sketch the graphs for the brick's speed and height as a function of time.

(a) $\boxed{y = -\frac{1}{2} g t^2 = -67\,m}$

(b) $\boxed{v_y = v_0 - gt = -gt = -36.3\,m/s}$

(c)





3.) *Projectile Launch* *(21 pts.)*

A projectile, starting from rest, is accelerated along a 120 m long ramp at a rate of 10.4 m/s^2. The ramp is inclined at an angle of 40° above the horizontal. After leaving the ramp, only gravity is acting.

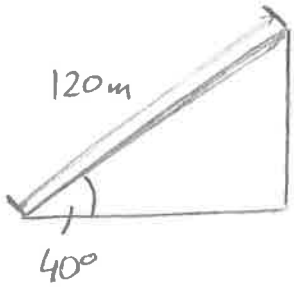
(a) Calculate the speed of the projectile when leaving the ramp.

(b) Calculate the maximal height reached by the projectile (relative to the exit point from the ramp).

(c) Calculate the horizontal displacement of the projectile (relative to the exit point from the ramp) when reaching the maximal height.

(a) $v^2 = v_0^2 + 2a\Delta x$ $\quad v_0 = 0$

$v = \sqrt{2a\Delta x} = 49.61 \frac{m}{s}$



(b) $v_y^2 = v_{oy}^2 - 2g\Delta y \quad \stackrel{!}{=} 0$ at maximal height

$\Rightarrow \Delta y_{max} = v_{oy}^2/2g = \frac{v^2 \sin^2\theta}{2g}$ $\quad v_{oy} = v \sin\theta$

$\Delta y_{max} = 52.6\ m$

(c) $\Delta x = v_{ox} t$

$= v \cos\theta\, t$

$= \frac{v^2 \sin\theta \cos\theta}{g}$

$\Delta x = 125\ m$

t from y-component:

$v_y = v_{oy} - gt \stackrel{!}{=} 0$

$\Rightarrow t = \frac{v_{oy}}{g} = 5.10\ s$

4.) *Tension Force* *(5+10 pts.)*

A uniform metal chain with a total mass of 150 kg can sustain a maximal tension of 4000 N in each of its identical links. The chain is deployed to lift a boulder of ore (mass 220 kg) attached to its end out of a quarry straight up.

(a) Which link along the chain experiences the maximal tension?

(b) What is the maximal acceleration with which the boulder can be lifted?

(a)  the uppermost link

(b) for the uppermost link

$$\sum F = ma \leq T_{max} - mg \qquad m = m_{chain} + m_{ore}$$

$$\Rightarrow \boxed{a \leq \frac{T_{max}}{m} - g = \underline{1.01 \ \frac{m}{s^2}}} \triangleq a_{max}$$

5.) *Friction and Normal Forces* *(5+10+10 pts.)*

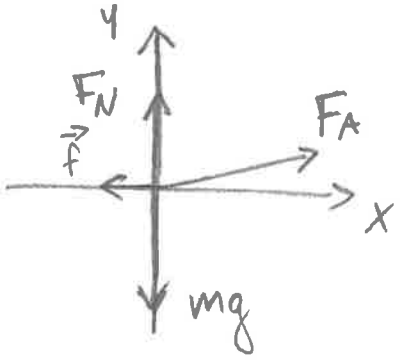
A dock worker pulls on a box (mass 85 kg) with force of 300 N at an angle of 10° above the horizontal. The static and kinetic friction coefficients between the box and the horizontal ground of the dockyard are 0.45 and 0.25, respectively.

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

(b) If the box is initially at rest, can the worker overcome the static friction force?

(c) If the box is moving, what is its acceleration?

(a)



(b) $m a_x = F_A \cos\theta - f_s^{max} = F_A \cos\theta - \mu_s F_N$

$0 = m a_y = F_N + F_A \sin\theta - mg \Rightarrow F_N = mg - F_A \sin\theta$

$\Rightarrow m a_x = F_A(\cos\theta + \mu_s \sin\theta) - \mu_s mg = -56N$

cannot get it moving

(c) $m a_x = F_A(\cos\theta + \mu_k \sin\theta) - \mu_k mg = 100.2\ N$

$\Rightarrow \boxed{a_x = \frac{100.2}{85} = 1.18\ \frac{m}{s^2}}$