Phys 111
Fall 2019
Exam #1
09/24/2019
Time Limit: 75 Minutes

Full Name: Solutions

(Print Clearly)

Version A

This exam contains 8 pages and 12 questions: 5 multiple choice (50 pts), 4 single part free response (80 pts), and 3 multi-part free repsonse (120 pts). Your score is graded out of 250 points. This exam is closed-resources, but some reference constants, conversions, and equations have been provided. The use of a **TI 30X IIS** non-graphing, non-programmable calculator is permitted, but cellphones are **not**.

Please use the attached extra paper instead of cramming your work on the pages with problem statements. If I can not read your work, I can not give you credit. Work **must** be explicitly shown to earn full credit including a justification of your methods.

Staple all of your scratch to the exam when you turn it in. A good test taking strategy is to cross out incorrect work instead of erasing it to save some time.

Good Luck!

Physical Constants

$$g \approx 10.0\, m/s^2$$

Conversion Factors

$$10^3\, m = 1\, km$$

$$3600\, s = 1.0\, h$$

Physical Relationships

$$\mathbf{v_{ag}} = \mathbf{v_{ab}} + \mathbf{v_{bg}}$$

$$v = 2\pi r/T$$

$$a_c = v^2/r$$

$$v_s = v_o + a_s t$$

$$s = s_o + v_{os}t + \frac{1}{2}a_s t^2$$

$$v_s^2 = v_o^2 + 2a_s(s - s_o)$$

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

$$f_s \le \mu_s F_N$$

$$f_k = \mu_k F_N$$

Multiple Choice: 50 points

+5 each for pencil

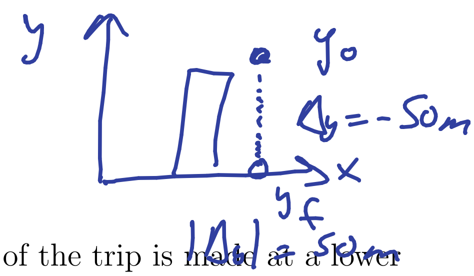
1. (10 points) What is the conversion factor for 1.0 m/s to km/h?
   - A. 1.0 m/s = 3.6 km/h
   - B. 1.0 m/s = 36.0 km/h
   - C. 1.0 m/s = 0.278 km/h
   - D. 1.0 m/s = 2.78 km/h

$$\frac{1.0\,m}{s} \cdot \frac{3600\,s}{1\,h} \cdot \frac{1\,km}{1000\,m} = \frac{3600}{1000}\frac{km}{h} = 3.6\,km/h$$

2. (10 points) What type of quantity is velocity and how is it defined?
   - A. Scalar; Distance traveled divided by elapsed time.
   - B. Scalar; Change in position divided by elapsed time.
   - C. Vector; Distance traveled divided by elapsed time
   - D. Vector; Change in position divided by elapsed time.

$$\vec{v} = \frac{d\vec{x}}{dt} \approx \frac{\Delta\vec{x}}{\Delta t}$$

3. (10 points) If you drop a ball off of a building with a height of 50 meters and it hits the ground, what would be its total displacement and distance traveled? Choose the upwards direction to be positive.
   - A. Displacement is 50 meters, Distance is 50 meters
   - B. Displacement is 50 meters, Distance is -50 meters
   - C. Displacement is -50 meters, Distance is 50 meters
   - D. Displacement is -50 meters, Distance is -50 meters



4. (10 points) A car travels a distance of 360.0 km. The first part of the trip is made at a lower speed than the second part. If it takes 3.0 h to complete the trip, what is the average speed of the car during the trip?
   - A. 60 km/h
   - B. 120 km/h
   - C. 240 km/h
   - D. 360 km/h

$$speed_{ave} = \frac{distance}{time} = \frac{360.0\,km}{3.0\,h} = 120\,\frac{km}{h}$$

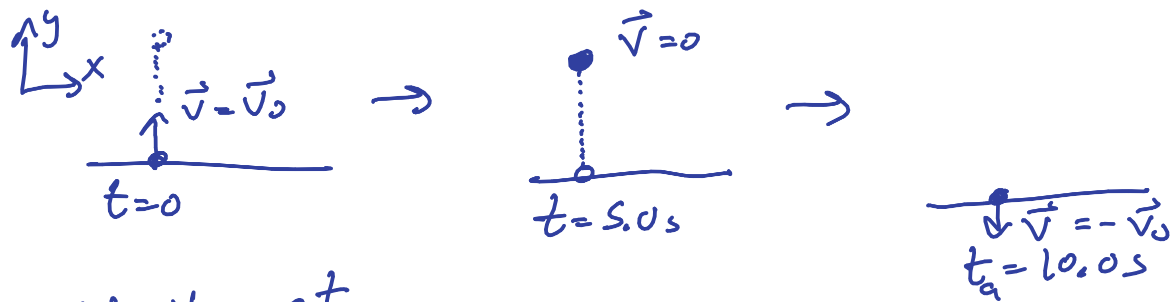
5. (10 points) A 35.0 kg object moves from left to right at a speed of 20.0 km/h. What net force is required to keep this object moving in a straight line at constant speed?
   - A. 700 N
   - B. 35 N
   - C. 20 N
   - D. 0 N

move w/ constant speed in a straight line means constant velocity.

const. $\vec{v} \Leftrightarrow \vec{a} = 0 \Leftrightarrow \vec{F} = 0$

Free-Response: 80 points

1. (20 points) A ball is thrown vertically upward, which is chosen as a positive direction. A little later it returns to its point of release. The ball is in the air for a total time of 10.0 s. What is its initial velocity?



$v = v_0 - gt$

$v = 0$ @ $t_h = 5.0\,s$

$v_0 - g t_h = 0$

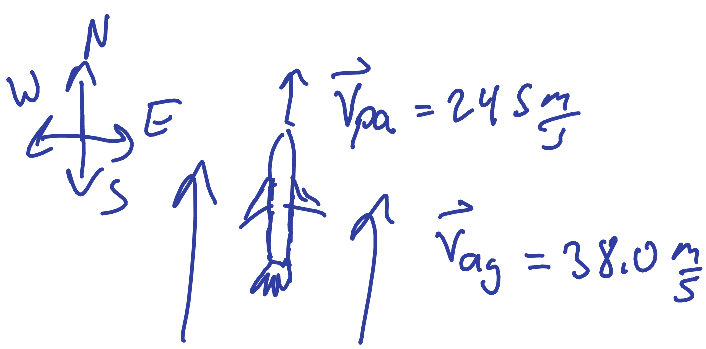
$v_0 = g t_h$

$t_a = 2 t_h$

$$v_0 = g\frac{t_a}{2} = \left(10.0\frac{m}{s^2}\right)\left(\frac{10.0\,s}{2}\right) = \boxed{10.0\frac{m}{s}}$$

+10 +10

2. (20 points) The captain of a plane flies a plane due north. The cruising speed of the plane is 245 m/s relative to the air when a 38.0 m/s wind starts to blow from the south to the north. How fast does the plane fly relative to the ground since the airplane has a tailwind that speeds it up?



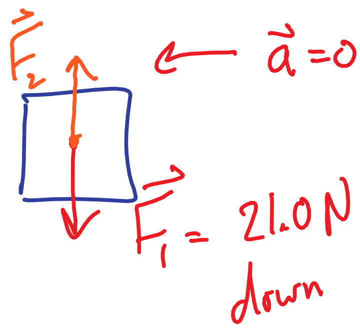
$\vec{v}_{pg} = \vec{v}_{pa} + \vec{v}_{ag}$

$\vec{v}_{pg} = +(245 + 38.0)\frac{m}{s}$ North

$$\boxed{\vec{v}_{pg} = 283\frac{m}{s}\ N}$$ or $$\boxed{v_{pg} = 283\frac{m}{s}}$$

+10 +10

3. (20 points) Consider an object that has two forces acting vertically on it. Use a standard x-y coordinate system for this problem where +y means vertically up. It turns out the first force $\mathbf{F}_1 = 21.0\,N$ downward and the mass of the box is $7.0\,kg$. What must the magnitude and direction of $\mathbf{F}_2$ be to cause no acceleration.



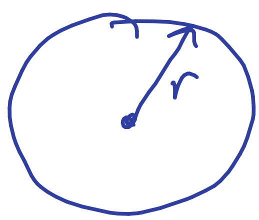
$\leftarrow \vec{a}=0 \rightarrow \vec{F}_{net} = \Sigma \vec{F} = \vec{F}_1 + \vec{F}_2 = 0$

$\vec{a} = 0 \rightarrow$ net force $= 0 \rightarrow \vec{F}_1 + \vec{F}_2 = 0$

or $\vec{F}_2 = -\vec{F}_1 \rightarrow \boxed{\vec{F}_2 = 21.0\text{N upward}}$

+10 +10

4. (20 points) A car travels with a constant speed around a circular track with a radius of 260 m. The car goes once around the track in 52 s. What is the magnitude of the centripetal acceleration of the car?



$V = \frac{2\pi r}{T} = \frac{2\pi(260m)}{(52s)}$

$V = 31.42\frac{m}{s}$

$a_c = \frac{v^2}{r} = \frac{\left(\frac{2\pi r}{T}\right)^2}{r} = \frac{4\pi^2}{T^2}\frac{r^2}{r}$

$a_c = \frac{4\pi^2 r}{T^2}$

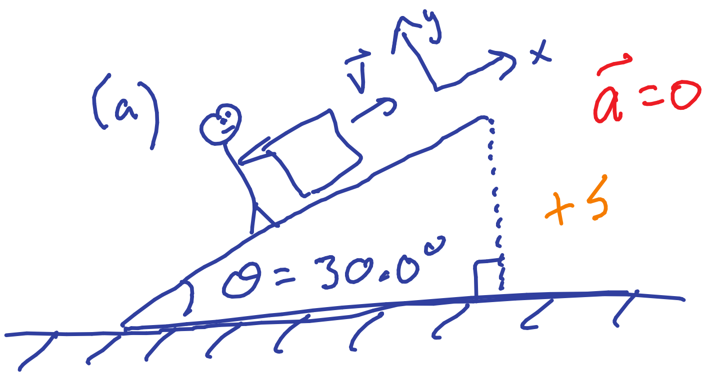
$a_c = \frac{(31.42\frac{m}{s})^2}{(260m)}$ or $\frac{4\pi^2(260m)}{(52s)^2} = \boxed{3.80\frac{m}{s^2}}$ +10

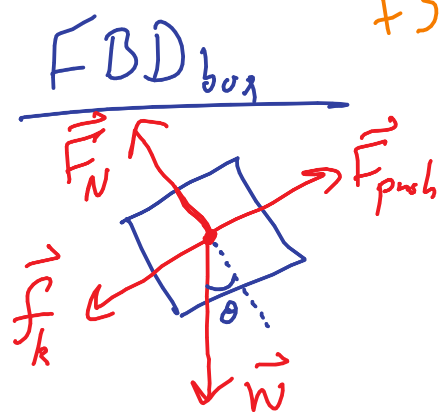
+10

Multi-Part: 120 points

1. (40 points) A 30.0 kg (m) crate rests on a ramp that has a 30.0° (θ) angle at a shipping dock. The coefficient of kinetic friction is 0.400 (μ_k).
   (a) (10 points) Sketch the ramp, box, and indicate your coordinate system. Then draw a FBD for the box.
   (b) (10 points) Write down the appropriate force equations for the FBD of the crate.
   (c) (10 points) What is the weight of the box and the normal force on the crate from the ramp?
   (d) (10 points) What pushing force is required to push the crate up the ramp at a constant speed after overcoming static friction?

(a)





(b) $\sum \vec{F} = 0 \rightarrow$

$\vec{F}_{push} + \vec{f}_k + \vec{F}_N + \vec{W} = 0$

$$\begin{cases} F_x = F_{push} - f_k - W\sin\theta = 0 & +5 \\ F_y = F_N - W\cos\theta = 0 & +5 \end{cases}$$

(c) $W = mg = (30.0\,\text{kg})(10.0\,\frac{\text{m}}{\text{s}^2})$

$\boxed{W = 300\ \text{N}}$ +5

From $F_y = 0 \rightarrow F_N = W\cos\theta$

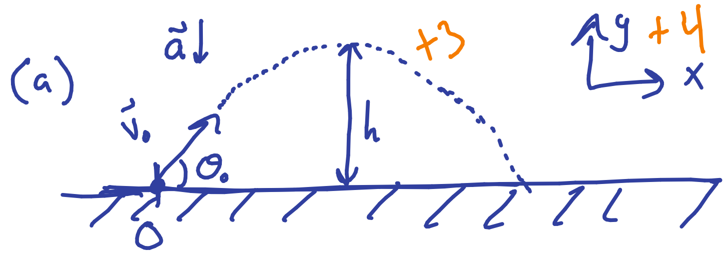
$\boxed{F_N = 260\ \text{N}}$ +5

(d) must know $f_k = \mu_k F_N \rightarrow F_{push} = f_k + W\sin\theta$ +5

$\boxed{F_{push} = 254\ \text{N}}$ +5

2. (40 points) A projectile is launched at an angle of 60.0° from the horizontal and reaches a max vertical height of 14.0 m.
   (a) (10 points) Sketch said projectile being launched, indicate your coordinate system, and write down corresponding kinematic equations.
   (b) (10 points) What is the projectile's launch speed?
   (c) (10 points) How long is it in the air if it lands at the same height as it was launched?
   (d) (10 points) How far horizontally does the projectile travel before landing?

(a)



$h = 14.0\,m$
$\theta_0 = 60.0°$
$g = 10.0\,\frac{m}{s^2}$
$x_0 = 0$
$y_0 = 0$

$a_x = 0\ ,\ a_y = -g$

$V_x = V_{0x} = V_0 \cos\theta_0$
$x = V_x t$
$x = V_0 \cos\theta_0\, t$ +1

$V_y = V_{0y} - gt = V_{0y} \sin\theta_0 - gt$
+2 $y = V_{0y} t - \frac{g}{2} t^2$
$V_y^2 = V_{0y}^2 - 2gy$

(b) $V_y = 0$ +5 @ $y = h = 14.0\,m \rightarrow V_{0y}^2 = 2gh$

$V_{0y} = \sqrt{2gh} = \sqrt{2(10\frac{m}{s^2})(14.0\,m)} = 16.7\,\frac{m}{s}$

$V_{0y} = V_0 \sin\theta_0 \rightarrow V_0 = \frac{V_{0y}}{\sin\theta} = \frac{16.7\frac{m}{s}}{\sin 60°} = 19.3\,\frac{m}{s}$

$\boxed{V_0 = 19.3\,\frac{m}{s}}$ +5

(c) time in air = 2(time to h) +5

$V_y = 0 = V_{0y} - g t_h$
$t_h = \frac{V_{0y}}{g} = 1.67\,s$

$\boxed{t_{air} = 3.34\,s}$ +5

(d) $X = V_0 \cos\theta_0\, t_{air} = (19.3\,\frac{m}{s}) \cos 60° (3.34\,s)$ +5

$\boxed{X = 32.2\,m}$ +5

3. (40 points) A person who walks for exercise produces the position–time graph below.

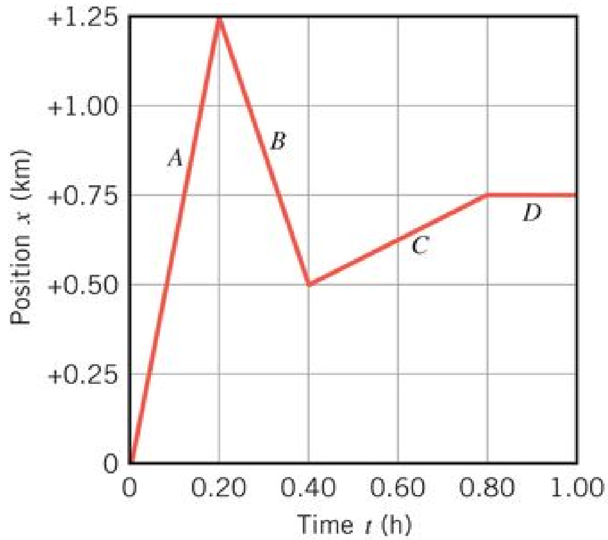


Figure 1: Exam #1 Multi-part Problem 3

if, but this wrong

+30

Calculate the average velocity for

(a) (10 points) segment A

(b) (10 points) segment B

(c) (10 points) segment C

(d) (10 points) segment D

$$\bar{v} = \vec{v}_{ave} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

(a) $\bar{v}_a = \frac{1.25 - 0}{0.20 - 0} \frac{km}{h}$ +5 $\boxed{= +6.25 \frac{km}{h}}$ +3 +2 (a)

(b) $\bar{v}_b = \frac{0.50 - 1.25}{0.40 - 0.20} \frac{km}{h}$ +5 $\boxed{= -3.75 \frac{km}{h}}$ +3 +2 (b)

(c) $\bar{v}_c = \frac{0.75 - 0.50}{0.80 - 0.40} \frac{km}{h}$ +5 $= \boxed{+0.625 \frac{km}{h}}$ +3 +2 (c)

(d) $\boxed{\bar{v}_d = 0 \frac{km}{h}}$ +10 $= \frac{0.75 - 0.75}{1.00 - 0.80} = 0 \frac{km}{h}$