General Physics I
SUNY Geneseo

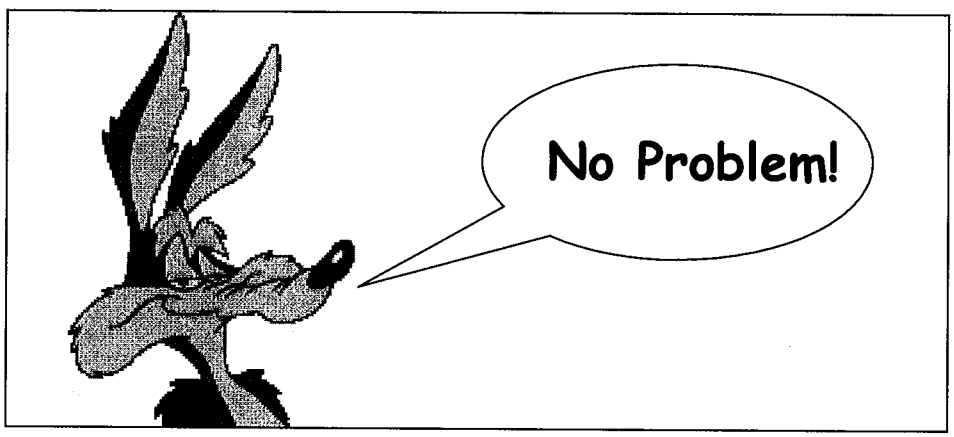
Dr. Pogo
September 29, 2009

Exam #1

Name : Solution

Instructions for the exam:

1) Use a pencil, not a pen.
2) Use at least 3 Sig Figs in all calculations.
3) The exam is closed book and closed notes. You may use your calculators. Also, formulae (which may or may not be useful) are provided on the last page of the exam.
4) Read each problem carefully. To receive partial credit, you must show all of your work. Include coordinate systems, equations, units, and pictures as needed. Put a box around your answers. You are not required to solve the problems in order, so if you get stuck, move on to another problem for a while.
5) There are five problems, each with several parts. The point value for each part is indicated in [square brackets].
6) Print your last name on every page.
7) For problems that take place on the surface of a planet, you may neglect air resistance and the effects of the planet's curvature.



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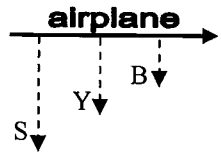
Problem #1: [35 points] Short Answers (a) through (j)

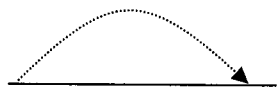


a. [3] Sylvester the Cat (m_S = 30 kg), Yosemite Sam (m_Y = 40 kg), and Bugs Bunny (m_B = 20 kg) all drop out of a horizontally moving airplane, starting at different times in the order listed. Rank the three (S, Y, B) in order of the magnitude of their acceleration, from smallest to largest.

$a_y = -g$ for all

$S = Y = B$

b. [3] On a horizontal surface, the Coyote fires a cannon at the roadrunner four times (A, B, C, D), all with the same initial speed, but with the different initial angles shown below. Rank the horizontal distance traveled for these shots, from shortest to longest.

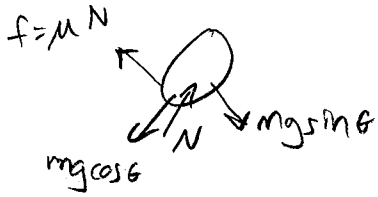


$\theta_{0A} = 22°$ $\theta_{0B} = 38°$ $\theta_{0C} = 58°$ $\theta_{0D} = 68°$

$R = \frac{v^2}{g}\sin(2\theta)$ → care about only $\sin(2\theta)$

$A = D < C < B$

c. [3] Sylvester the Cat (m_S = 30 kg), Yosemite Sam (m_Y = 40 kg), and Bugs Bunny (m_B = 20 kg) all stand on a ramp inclined at an angle of θ=22°. The coefficients of friction for each are $\mu_{sS} = 0.15$, $\mu_{sY} = 0.20$, and $\mu_{sB} = 0.25$. Rank these three in order of the magnitude of the normal force they exert on the ramp, from smallest to largest.



$N = mg\cos\theta$ → only care about m

$B < S < Y$

d. [4] Using the same information as given in part c, rank these three in order of the magnitude of the frictional force they exert on the ramp, from smallest to largest.

$f = \mu \cdot mg\sin\theta$ → care about $(\mu \cdot m)$

$\mu m_S = 4.5$

$\mu m_Y = 8.0$

$\mu m_B = 5.0$

$S < B < Y$

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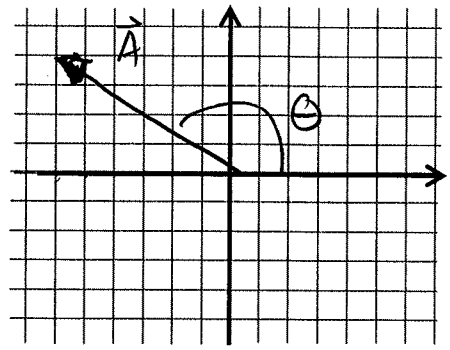
e. [3] The roadrunner has the displacement vector $\vec{A} = -6\text{km}\hat{x} + 4\text{km}\hat{y}$. Sketch this vector, then compute its correct angle and magnitude. Hint: Make sure that your sketch agrees with your answers.



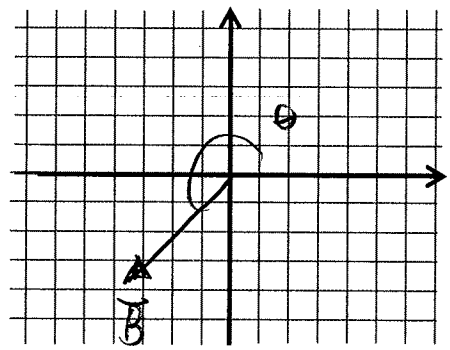
Magnitude: 7.21 km

Angle: 146.3°

$\theta = \text{atan}\left(\frac{4}{-6}\right) + 180°$

$|A| = \sqrt{6^2 + 4^2}$

f. [3] A vector $\vec{B}$ has a magnitude of 5km, and an angle $\theta = 226°$. Compute the components, and sketch this vector.



$B_x =$ -3.47 km $B_y =$ -3.60 km

$B_x = B\cos\theta$

$B_y = B\sin\theta$

g. [4] Given: $\vec{C} = +3\text{km}\hat{x} - 2\text{km}\hat{y}$, and $\vec{D} = \vec{A} - \vec{B} + \vec{C}$ (uses the vectors $\vec{A}$ and $\vec{B}$ from above). Determine the components of $\vec{D}$.

$D_x =$ 0.47 km $D_y =$ 5.60 km

X	Y
$A_x - B_x + C_x$	$A_y - B_y + C_y$
$-6 - (-3.47) + 3$	$4 - (-3.60) + (-2)$

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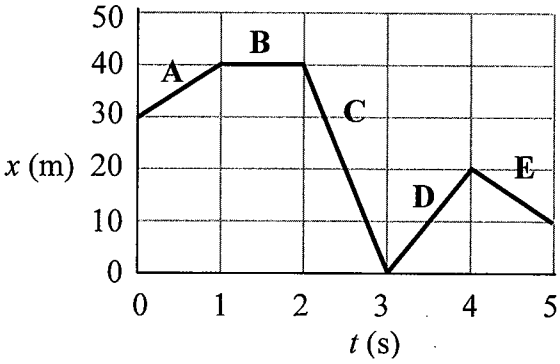
Questions 1h through 1l use the plot shown here, showing the position of the Roadrunner as a function of time.



h. [2] In what region(s) (A, B, etc.) is the speed the highest? C

i. [2] In what region(s) is the speed the lowest? B

j. [2] What is the speed at $t = 2.5$s? 40 m/s

k. [2] What is the acceleration at $t = 2.5$s? 0 m/s^2

l. [2] How many times does he pass his starting point? 1

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m. [2] Unit Conversion:
12 rockets cost \$45
3 rockets cost the same amount as 16 parachutes
5 springs cost the same amount as 12 parachutes
How many springs can the Coyote buy for \$108?

$$\$108 \times \frac{12\,R}{\$45} \times \frac{16\,P}{3\,R} \times \frac{5\,S}{12\,P} = 64 \text{ springs}$$

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Problem #2: [10 points] The Coyote slips on some spilled oil. He slides (with constant acceleration) a distance of 84m in 14 seconds until he finally comes to a complete stop.

a. [5] What was the Coyote's initial speed?
b. [5] What was the magnitude of the Coyote's acceleration?

$x_0 = 0$
$x_f = 84m$
$v_0 = ?$
$v_f = 0$
$a = ?$
$\Delta t = 14s$

EQ 4: $x_f = x_0 + \frac{1}{2}(v_0 + v_f)\Delta t$

$$v_0 = \frac{2x_f}{\Delta t} \Rightarrow v_0 = 12 m/s$$

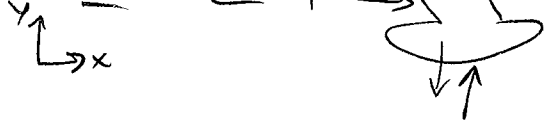
EQ 2: $v_f = v_0 + a\Delta t$

$$a = -\frac{v_0}{\Delta t} = -\frac{2x_f}{\Delta t^2} \Rightarrow a = -0.857 m/s^2$$

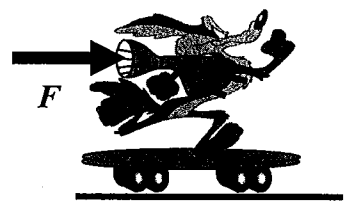
Problem #3: [12 points] The Coyote ($m_1 = 40$ kg), wearing a jetpack that exerts a force F, rides a skateboard ($m_2 = 15$ kg) as shown. Although there is no friction between the skateboard and the ground, there is friction ($\mu_s = 0.60$) between the Coyote and the skateboard. Assuming that the Coyote does not fall off:

c. [6] What is the Coyote's acceleration?
d. [6] What was the maximum force F that may be exerted by the jetpack?

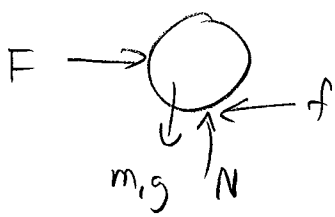
FBD: Both



$\Sigma F_x = m_{tot} a_x$
$F = (m_1 + m_2) a$



FBD: Coyote



$\Sigma F_y = m_1 a_y = 0$
$N - m_1 g = 0 \Rightarrow N = m_1 g$

$\Sigma F_x = m_1 a_x$
$F - f = m_1 a_x$
$F - \mu_s \cdot m_1 g = m_1 a$
$m_1 a + m_2 a - \mu_s m_1 g = m_1 a \Rightarrow$

$$a = \frac{\mu_s m_1 g}{m_2}$$

$a = 15.68 m/s^2$

$F = (m_1 + m_2) a \Rightarrow F = 862.4 N$

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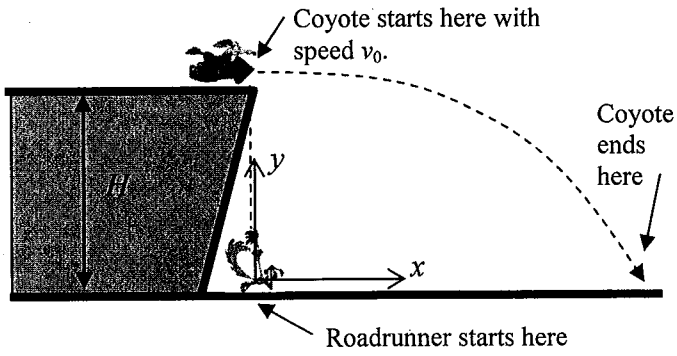
Problem #4: [22 points] The Coyote is driving a rocket horizontally on top of a cliff. As the roadrunner passes directly below him, the Coyote passes over the side of a cliff, and immediately begins to "free fall".
The cliff is $H = 40$m tall, and the initial speed of the Coyote is $v_0 = 20$m/s. A coordinate system is already given; you may not make another.



a. [8] There are 10 blanks in the table to the right. Fill in the 8 remaining known quantities using symbols, not numbers. Note: Zero is a symbol.
b. [4] How long (Δt) is the coyote airborne?
c. [5] Where (x_{fC}) does the coyote hit the ground?
d. [5] Where is the Roadrunner (x_{fR}) at this time?

Coyote:	
$x_{0C} = 0$	$y_{0C} = H$
$x_{fC} = ?$	$y_{fC} = 0$
$v_{ixC} = v_0$	$v_{iyC} = 0$
$a_{xC} = 0$	$a_{yC} = -g$

Roadrunner:	
$x_{0R} = 0$	
$x_{fR} = ?$	
$v_{ixR} = +17$ m/s	
$a_{xR} = +3.1$ m/s^2	

b) EQ 1y: $y_{fC} = y_{0C} + v_{0C} t + \frac{1}{2} a_{yC} t^2$

$0 = H + 0 - \frac{1}{2} g t^2 \rightarrow$

$t = \sqrt{\frac{2H}{g}}$ $\quad t = 2.857\,s$

c) EQ 1x: $x_{fC} = x_{0C} + v_{0xC} t + \frac{1}{2} a_{xC} t^2$

$x_{fC} = v_0 t = v_0 \sqrt{\frac{2H}{g}} = x_{fC}$ $\quad x_{fC} = 57.14\,m$

d) EQ 1x: $x_{fR} = x_{0R} + v_{0Rx} t + \frac{1}{2} a_{xR} t^2$

$x_{fR} = 0 + 48.57\,m + 12.652\,m = x_{fR} = 61.22\,m$

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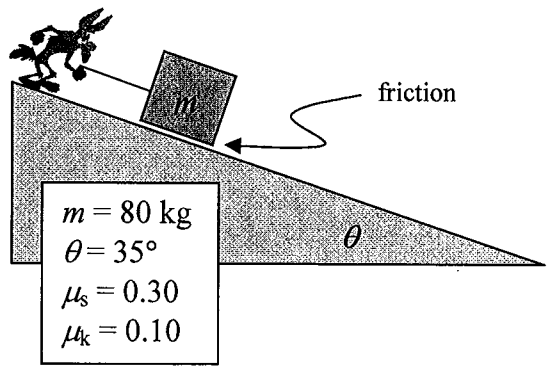
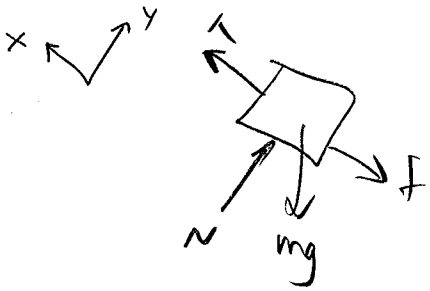
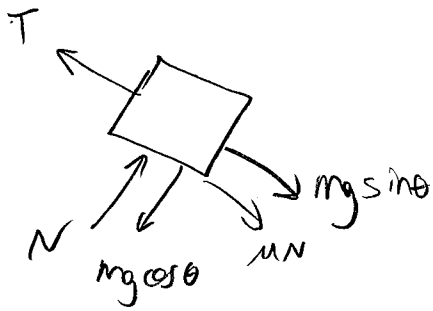
Problem #5: [21 points] The Coyote tries to use a rope to pull a box of dynamite up a hill. Hint: Use symbols!

a. [7] What tension is needed to start the box moving?
b. [7] What is the tension if the box moves at a constant velocity?
c. [7] What is the acceleration of the box if the tension is 700N?







$\Sigma F_y = 0 \Rightarrow N = mg\cos\theta$

$\Sigma F_x = ma_x$

$T - mg\sin\theta - \mu \cdot mg\cos\theta = ma$

$$T = ma + mg\sin\theta + \mu\, mg\cos\theta$$ ★

or

$$a = \frac{T}{m} - g\sin\theta - \mu g\cos\theta$$

Part a) $a = 0$, $\mu = \mu_s$

$T = 642.4\,N$

Part b) $a = 0$, $\mu = \mu_k$

$T = 513.9\,N$

Part c) $T = 700\,N$, $\mu = \mu_k$

$a = 2.327\ m/s^2$

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