Physics 4A
Fall 2025

Name Answer Key

Lab: 8:00 am 11:20 am 2:40 pm (circle one)

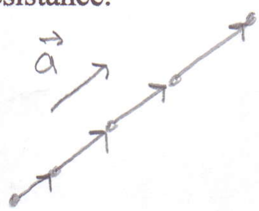
Celebration #1: Kinematics, Vectors, and Newton's Laws

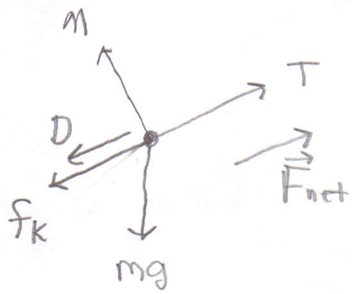
Short Answer Questions (4 or 5 points each)

(5 points)

1) For the situation described below, draw a motion diagram **and** a free-body diagram.

A tow rope pulls a skier up a snow-covered hill. The speed of the skier is increasing. There **is both** friction and air resistance.





(4 points)

2) The figure below shows three paths for a football kicked from ground level. Ignoring the effects of air resistance, ranks the paths according to **(a)** time of flight, **(b)** initial vertical velocity component, **(c)** initial horizontal velocity component, and **(d)** initial speed, **greatest first.**

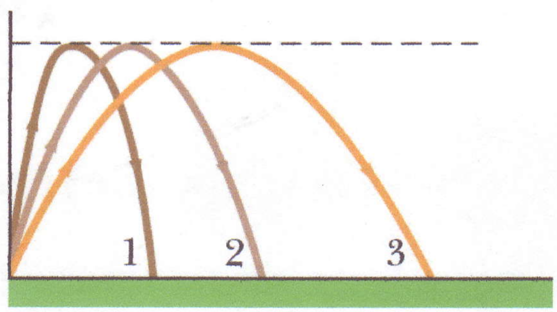
a) $\boxed{1 = 2 = 3}$

b $\boxed{1 = 2 = 3}$

since max height is same

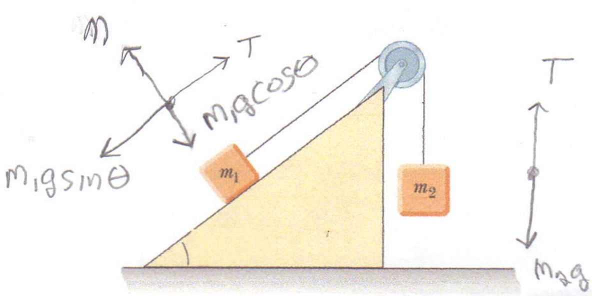
c) $\boxed{3 > 2 > 1}$ → since time in air is same

d) $\boxed{3 > 2 > 1}$ ↘ since V_{oy} is same can rank by V_{ox}



(5 points)

3) Two blocks, with masses $m_1 = 25.0$ kg and $m_2 = 10.0$ kg, are connected by a string of negligible mass passing over a massless, frictionless pulley as shown in the figure below. The incline is frictionless. What angle of the incline θ, will result in both blocks remaining at rest when they are released from rest?



$$m_1 g \sin\theta = m_2 g$$

$$\sin\theta = m_2/m_1$$

$$\theta = \sin^{-1}(m_2/m_1) = \sin^{-1}\left(\frac{10.0\text{kg}}{25.0\text{kg}}\right)$$

$$\boxed{\theta = 23.6^\circ}$$

$\Sigma F_x = ma_x = 0$

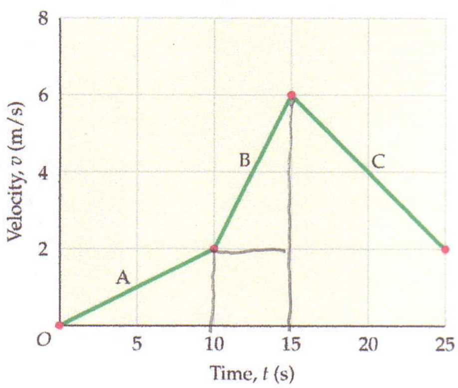
$T = m_1 g \sin\theta$

$\Sigma F_y = 0$

$T = m_2 g$

(5 points)

4) The figure below shows the velocity versus time graph for a particle having an initial position of $x_0 = 25$ m at $t = 0$ s. (a) What is the particle's position at $t = 15$ s? (b) What is the particle's acceleration at $t = 20$ s? *Assume two significant figures and justify your answers.*



$$\text{area} = \tfrac{1}{2}(10s)(2m/s) + (5s)(2m/s) + \tfrac{1}{2}(5s)(4m/s) = \underline{30.\,m}$$

$$X_f = X_i + \Delta X = 25m + 30.m = \boxed{55m}$$

(b) $$a = \frac{\Delta V}{\Delta t} = \frac{2m/s - 6m/s}{25s - 15s} = \boxed{-0.40\,m/s^2}$$

(4 points)

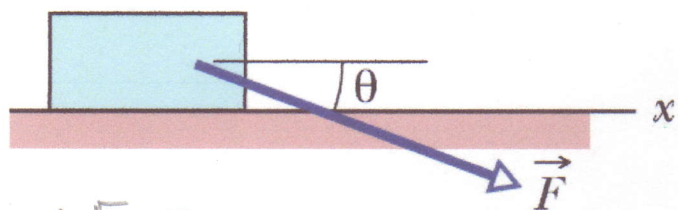
5) In the figure below, if the box is stationary and the angle θ of force $\vec{F}$ is increased, do the following quantities increase, decrease, or remain the same:

a) f_s $\boxed{\text{decrease}}$

(Fcosθ decreases)

b) $f_{s,max}$? $\boxed{\text{increase}}$

(n increases)



n

f_s ← → Fcosθ → decreases as θ increases

Fsinθ → increases

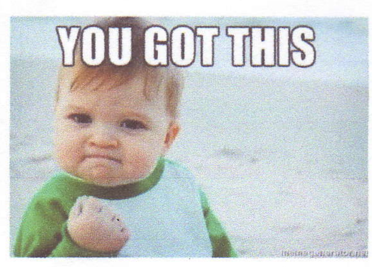
(5 points)

6) How far, **in centimeters**, does a disgruntled physics student travel if they walk at a constant speed of 2.50 × 10^5 mm/μs (millimeters per microsecond) for 12 straight hours?

$$2.50\times10^5\,mm/\mu s \left(\frac{1cm}{10mm}\right)\left(\frac{1\mu s}{10^{-6}s}\right) = \underline{2.50\times10^{10}\,cm/s}$$

$$12\,hours\left(\frac{3600s}{1hr}\right) = \underline{43{,}200s}$$

$$\text{distance} = (2.50\times10^{10}\,cm/s)(43{,}200s) = \boxed{1.08\times10^{15}\,cm}$$



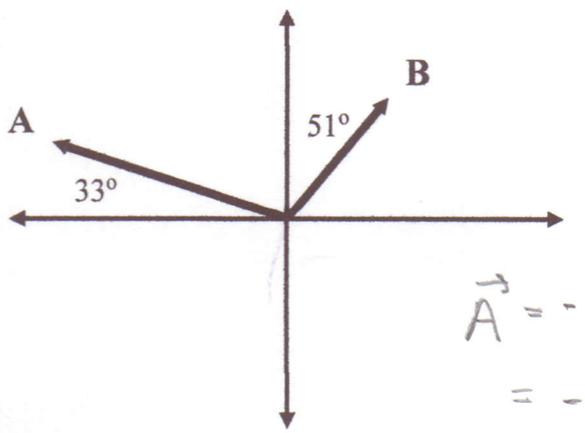
Problems (12 points each)

Problem 1

Two force vectors, $\vec{A}$ and $\vec{B}$, are shown in the figure below. Force $\vec{A}$ has a magnitude of 15.0 N and force $\vec{B}$ has a magnitude of 8.50 N. Find the magnitude and direction of a third force vector $\vec{C}$ such that $3\vec{A} - 5\vec{B} + 2\vec{C} = 0$

$$2\vec{C} = 5\vec{B} - 3\vec{A}$$

$$\vec{C} = 5/2\,\vec{B} - 3/2\,\vec{A}$$



$$\vec{A} = -(15.0N)\cos 33°\,\hat{i} + (15.0N)\sin 33°\,\hat{j}$$

$$= -(12.6N)\hat{i} + (8.17N)\hat{j}$$

$$\vec{B} = (8.50N)\sin 51°\,\hat{i} + (8.50N)\cos 51°\,\hat{j}$$

$$= (6.61N)\hat{i} + (5.35N)\hat{j}$$

$$C_x = 5/2\,B_x - 3/2\,A_x = 5/2(6.61N) - 3/2(-12.6N) = 35.4N$$

$$C_y = 5/2\,B_y - 3/2\,A_y = 5/2(5.35N) - 3/2(8.17N) = 1.12N$$

$$|\vec{C}| = \sqrt{C_x^2 + C_y^2} = \sqrt{(35.4N)^2 + (1.12N)^2} = \boxed{35.4N}$$

$$\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \tan^{-1}\left(\frac{1.12N}{35.4N}\right) = \boxed{1.81°}$$

Problem 2
A stone is dropped from the roof off of a very tall building. 2.25 s later, a second stone is thrown straight down at 12.5 m/s. How far apart are the stones when the second stone has reached a speed of 48.0 m/s?

second stone

y_0	y	V_{oy}	V_y	a_y	t
0 m	?	−12.5 m/s	−48.0 m/s	−9.80 m/s²	?

$$V_y = V_{oy} + a_y t \rightarrow t = \frac{V_y - V_{oy}}{a_y} = \frac{-48.0\,m/s - (-12.5\,m/s)}{-9.80\,m/s^2}$$

$$t = 3.62\,s$$

$$y = \underbrace{y_0}_{=0} + V_{oy}t + \tfrac{1}{2}a_y t^2$$

$$y = (-12.5\,m/s)(3.62\,s) + \tfrac{1}{2}(-9.80\,m/s^2)(3.62\,s)^2 = -109.5\,m$$

first stone

y_0	y	V_{oy}	V_y	a_y	t
0 m	?	0 m/s	?	−9.80 m/s²	2.25 s + 3.62 s = 5.87 s

$$y = \underbrace{y_0}_{=0} + \underbrace{V_{oy}}_{=0}t + \tfrac{1}{2}a_y t^2$$

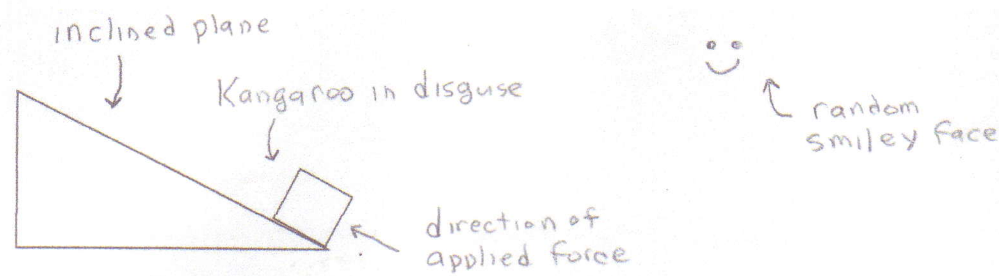
$$y = \tfrac{1}{2}(-9.80\,m/s^2)(5.87\,s)^2 = -168.8\,m$$

$$\Delta y = -109.5\,m - (-168.8\,m)$$

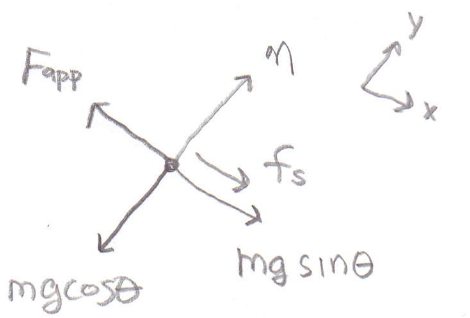
$$\boxed{\Delta y = 59.3\,m}$$

Problem 3

A 65.0 kg kangaroo, brilliantly disguised as a box, is at rest (after a long day of jumping) at the bottom of the 35.0° inclined plane as shown in the very-detailed figure below. The coefficients of static and kinetic friction between the kangaroo and the inclined plane are $\mu_s = 0.60$ and $\mu_k = 0.40$. How much force, parallel to the inclined plane, must be exerted to **(a)** start the box moving up the incline and **(b)** keep the box moving up the incline at a constant speed?



(a) to start box moving up incline, we must overcome $f_{s,max}$



$$\sum F_y = ma_y = 0$$

$$n = mg\cos\theta$$

$$\sum F_x = ma_x = 0$$

$$f_s + mg\sin\theta - F_{app} = 0$$

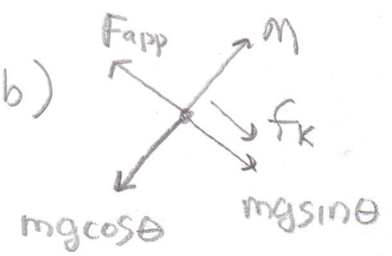
$$f_s = f_{s,max} = \mu_s n$$

$$F_{app} = \mu_s n + mg\sin\theta = \mu_s(mg\cos\theta) + mg\sin\theta$$

$$F_{app} = (0.60)(65.0\,kg)(9.80\,m/s^2)\cos 35.0° + (65.0\,kg)(9.80\,m/s^2)\sin 35.0°$$

$$\boxed{F_{app} = 678\,N}$$

(b)



$$\sum F_x = ma_x = 0$$

$$f_k + mg\sin\theta - F_{app} = 0$$

$$F_{app} = \mu_k(mg\cos\theta) + mg\sin\theta$$

$$F_{app} = (0.40)(65.0\,kg)(9.80\,m/s^2)\cos 35.0° + (65.0\,kg)(9.80\,m/s^2)\sin 35.0°$$

$$F_{app} = 574\,N$$

Problem 4

A baseball is thrown from an outfielder to the second baseman on a level field. The ball is in the air for a time t = 3.50 s and travels a horizontal distance of 92.0 m before being caught at the same height it was thrown from. Ignore air resistance.

a) What are the x- and y-components of the ball's initial velocity?

b) What is the maximum height of the ball?

c) When is the ball traveling at an angle of θ = –26.0°?

a) time to highest point $t = 1.75\,s$

y_0	y	V_{oy}	V_y	a_y	t
0	?	?	0 m/s	$-9.80\,m/s^2$	1.75 s

$$\underbrace{V_y}_{=0} = V_{oy} + a_y t$$

$$V_{oy} = -a_y t$$

$$= -(-9.80\,m/s^2)(1.75\,s)$$

$$\boxed{V_{oy} = 17.2\,m/s}$$

X_0	X	V_{ox}	t
0	92.0 m	?	3.50 s

$$X = \underbrace{X_0}_{=0} + V_{ox} t \rightarrow V_{ox} = \frac{X}{t} = \frac{92.0\,m}{3.50\,s} \rightarrow \boxed{V_{ox} = 26.3\,m/s}$$

b) $$y = \underbrace{y_0}_{=0} + V_{oy} t + \tfrac{1}{2} a_y t^2$$

$$y = (17.2\,m/s)(1.75\,s) + \tfrac{1}{2}(-9.80\,m/s^2)(1.75\,s)^2 \rightarrow \boxed{y = 15.1\,m}$$

c) find V_y when $\theta = -26.0°$ $\rightarrow$ $\tan\theta = V_y/V_x \rightarrow V_y = V_x \tan\theta$

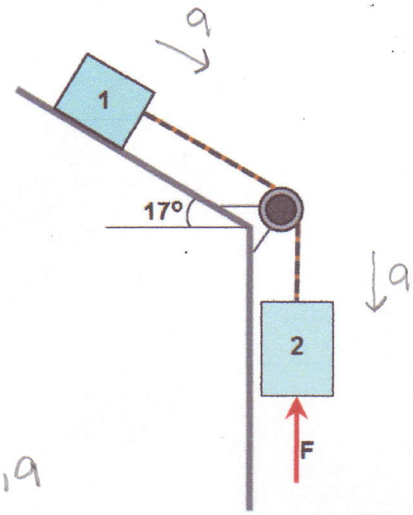
$$V_y = (26.3\,m/s)\tan(-26.0°) = \underline{\underline{-12.8\,m/s}}$$

$$V_y = V_{oy} + a_y t \rightarrow t = \frac{V_y - V_{oy}}{a_y} = \frac{-12.8\,m/s - (17.2\,m/s)}{-9.80\,m/s^2}$$

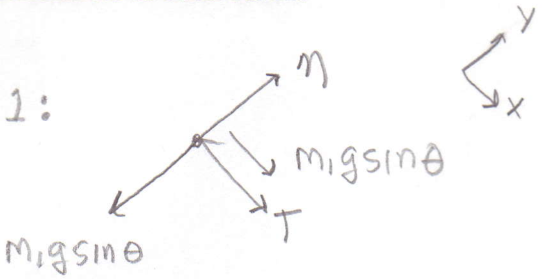
$$\boxed{t = 3.06\,s}$$

Problem 5

Two blocks are connected by a massless, stretchless rope passing over a massless, frictionless pulley. Block 1 of mass $m_1 = 1.0$ kg slides down a 17° frictionless inclined plane. An upward force of magnitude $F = 6.0$ N acts on block 2 of mass $m_2 = 2.0$ kg. Find the magnitude of the acceleration of each block.



block 1:



$$\sum F_x = m a_x$$

$$T + m_1 g \sin\theta = m_1 a$$

$$T = m_1 a - m_1 g \sin\theta \quad (1)$$

block 2:

define down as +

$$\sum F_y = m a_y$$

$$m_2 g - T - F = m_2 a \quad (2)$$

put (1) → (2) $\quad m_2 g - (m_1 a - m_1 g \sin\theta) - F = m_2 a$

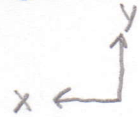
$$\boxed{a = \frac{m_2 g + m_1 g \sin\theta - F}{m_1 + m_2}}$$

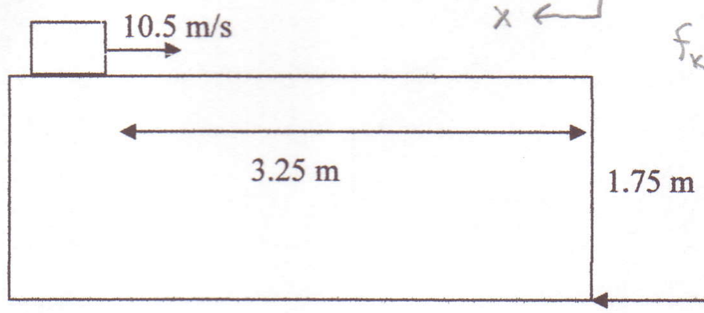
$$a = \frac{(2.0\,\text{kg})(9.80\,\text{m/s}^2) + (1.0\,\text{kg})(9.80\,\text{m/s}^2)\sin 17° - 6.0\,\text{N}}{1.0\,\text{kg} + 2.0\,\text{kg}}$$

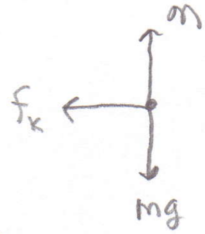
$$\boxed{a = 5.5\,\text{m/s}^2}$$

Problem 6

A disgruntled physics textbook is given an initial speed of 10.5 m/s when it is 3.25 m from the edge of a horizontal table that is 1.75 m tall. The coefficient of kinetic friction between the table and the textbook is $\mu_k = 0.40$. Assuming air resistance is negligible, how far from the base of the table does the block land?







$\sum F_y = ma_y = 0$

$n = mg$

$\sum F_x = ma_x$

$-f_k = ma_x$

$-\mu_k mg = ma_x$

$a_x = -\mu_k g = -(0.40)(9.80\,m/s^2)$

$a_x = -3.92\,m/s^2$

x_0	x	v_{0x}	v_x	a_x	t
0	3.25m/s	10.5 m/s	?	$-3.92\,m/s^2$	

$v_x^2 = v_{0x}^2 + 2a_x(x - \underset{=0}{x_0})$

$v_x = \sqrt{v_{0x}^2 + 2a_x} = \sqrt{(10.5\,m/s)^2 + 2(-3.92\,m/s^2)(3.25m)} \rightarrow v_x = 9.21\,m/s$

get time in air from vertical motion

y_0	y	v_{0y}	v_y	a_y	t
1.75m	0m	0m/s		$-9.80\,m/s^2$	?

$\overset{=0}{y} = y_0 + \overset{=0}{v_{0y}}t + \tfrac{1}{2}a_y t^2$

$t = \sqrt{\dfrac{-2y_0}{a_y}} = \sqrt{-\dfrac{2(1.75m)}{-9.80\,m/s^2}}$

$t = 0.598s$

x_0	x	v_{0x}	t
0m	?	9.21m/s	0.598s

$x = \underset{=0}{x_0} + v_{0x}t \longrightarrow x = (9.21\,m/s)(0.598s)$

$\boxed{x = 5.56m}$