Physics 11
Spring 2026

Name: Answer Key

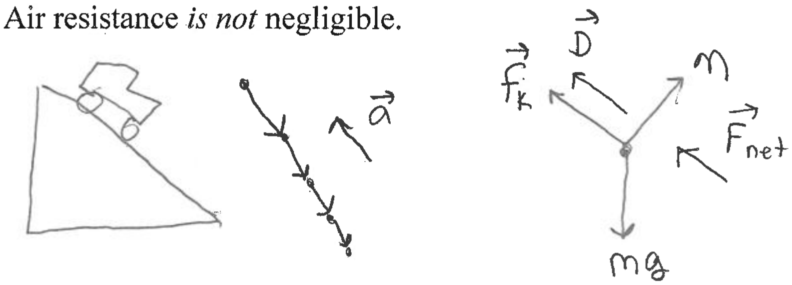
Clicker # ____________

Midterm Celebration

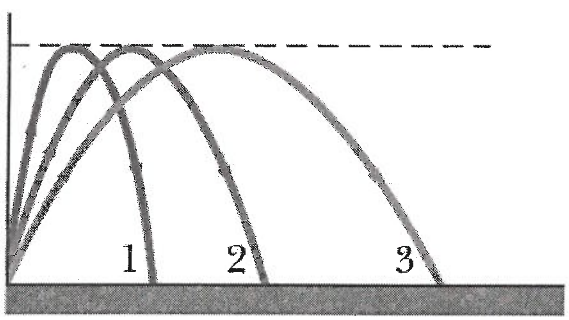
Short Answer Questions (5 or 6 points each)

(5pt) **1)** For the situation described below, draw a motion diagram **and** a free-body diagram.

You've slammed on the brakes and your car is skidding to a stop while going down a 20° hill. Air resistance *is not* negligible.



(6pt) **2)** The figure shows three paths for a football kicked from ground level. Ignoring the effects of air resistance, rank the paths according to **(a)** time of flight, **(b)** initial vertical velocity component, **(c)** initial horizontal velocity component, and **(d)** initial speed.



a) 1 = 2 = 3 (since all go to same max height)

b) 1 = 2 = 3

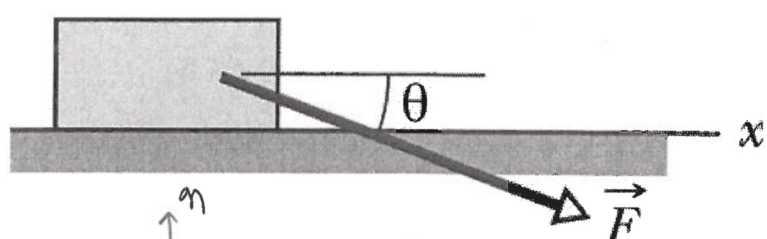
c) 3 > 2 > 1

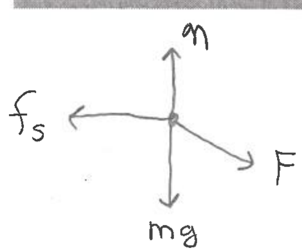
d) 3 > 2 > 1

(6pt) **3)** 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 decrease ($f_s = F_x$)

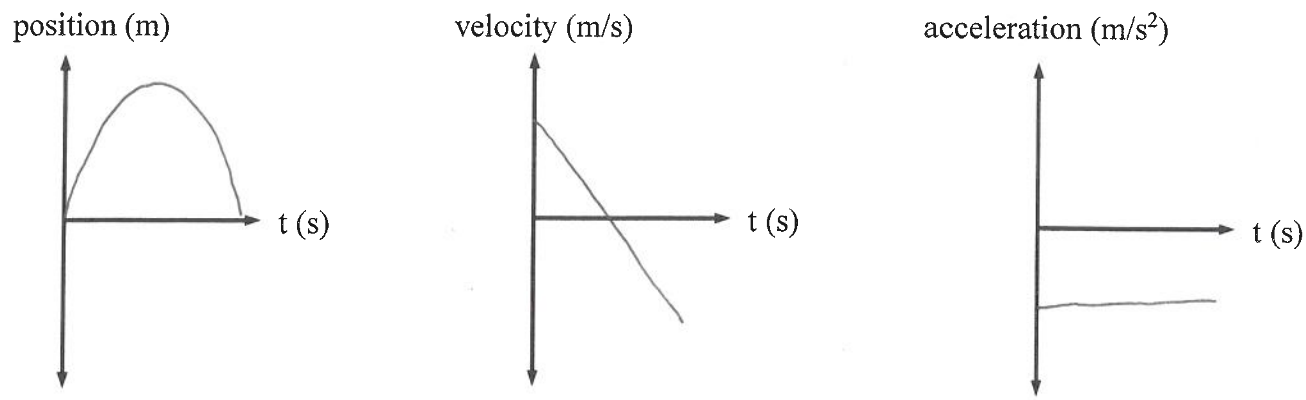
b) $f_{s,max}$? increase (since n increases)



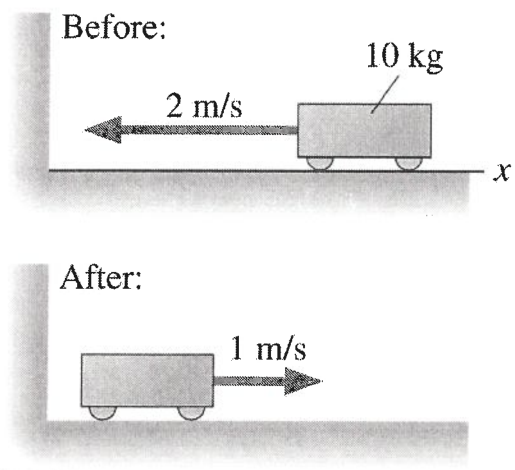


F_x decreases as θ increases

(6 pt) **4)** A ball is thrown vertically upward, rises to its maximum height, and returns to the thrower's hand. Sketch three different graphs showing the position, velocity, and acceleration of the ball as a function of time. Take upward to be the positive direction and the release point of the ball to be the zero position.



(5 pt) **5)** The figure below shows the collision of a cart with a wall. If the collision lasts for 3.25 ms, what is the average force that the wall exerts on the cart?



$m = 10\,\text{Kg}$

$\vec{v}_i = -2\,\text{m/s}$

$\vec{v}_f = 1\,\text{m/s}$

$\Delta t = 3.25 \times 10^{-3}\,\text{s}$

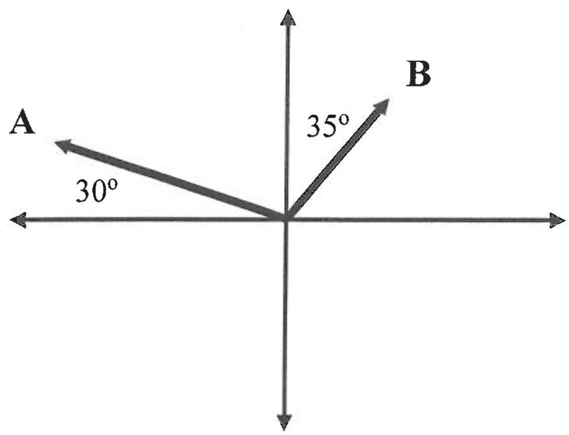
$\vec{F}_{ave} = ?$

$$\vec{F}_{ave}\,\Delta t = m(\vec{v}_f - \vec{v}_i) \rightarrow \vec{F}_{ave} = \frac{m(\vec{v}_f - \vec{v}_i)}{\Delta t}$$

$$\vec{F}_{ave} = \frac{(10\,\text{Kg})[1\,\text{m/s} - (-2\,\text{m/s})]}{3.25 \times 10^{-3}\,\text{s}} \rightarrow \vec{F}_{ave} = 9231\,\text{N} = 9 \times 10^{3}\,\text{N}$$

Problems (12 points each)

1) Two force vectors, $\vec{A}$ and $\vec{B}$, are shown below. Force $\vec{A}$ has a magnitude of 25.0 N and force $\vec{B}$ has a magnitude of 17.50 N. Find the magnitude and direction of $\vec{A}$ - $\vec{B}$.



$A_x = -(25.0N)\cos 30° = -21.7N$

$A_y = (25.0N)\sin 30° = 12.5\ N$

$B_x = (17.50N)\sin 35° = 10.0N$

$B_y = (17.50N)\cos 35° = 14.3N$

$\vec{C} = \vec{A} - \vec{B}$

$C_x = A_x - B_x = -21.7N - (10.0N) = -31.7N$

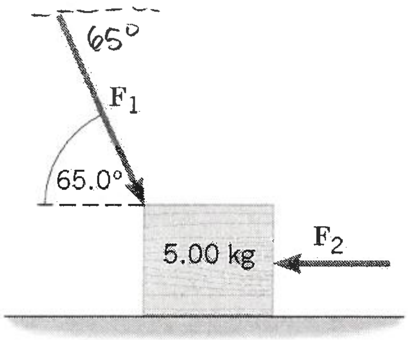
$C_y = A_y - B_y = 12.5N - 14.3N = -1.80N$

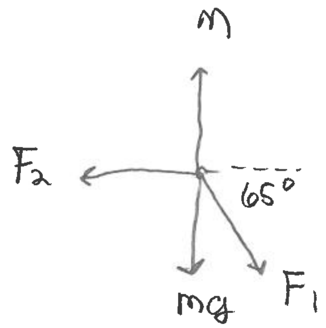
$|\vec{C}| = \sqrt{C_x^2 + C_y^2} = \sqrt{(-31.7N)^2 + (-1.80N)^2} = \boxed{31.8\ N}$

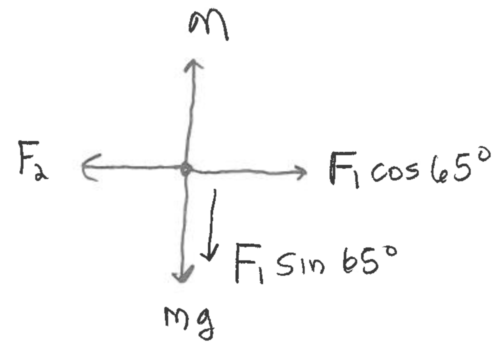
$\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = \tan^{-1}\left(\frac{-1.86N}{-31.7N}\right) = 3.2°$ → wrong quadrant

$\boxed{\theta = 183°}$

2) Two forces $\vec{F}_1$ and $\vec{F}_2$ act on the 5.00 kg block as shown in the figure below. The magnitudes of the forces are $F_1 = 45.0$ N and $F_2 = 25.0$ N.







(a) What is the normal force on the block?

$$\sum F_y = m a_y = 0$$

$$n - mg - F_1 \sin 65° = 0$$

$$n = mg + F_1 \sin 65° = (5.00\,\text{kg})(9.80\,\text{m/s}^2) + (45.0\,\text{N}) \sin 65°$$

$$\boxed{n = 89.8\,\text{N}}$$

(b) What is the horizontal acceleration (magnitude and direction) of the block assuming the floor is frictionless?

$$\sum F_x = m a_x$$

$$F_1 \cos 65° - F_2 = m a_x \longrightarrow a_x = \frac{F_1 \cos 65° - F_2}{m}$$

$$a_x = \frac{(45.0\,\text{N}) \cos 65° - 25.0\,\text{N}}{5.0\,\text{kg}} = -1.20\,\text{m/s}^2$$

$$\boxed{a_x = 1.20\,\text{m/s}^2 \text{ to the left}}$$

3) A model rocket fired vertically from the ground ascends with a constant vertical acceleration of 15.50 m/s² for 12.50 s. Its fuel is then exhausted, so it continues upward as a free-fall particle and then falls back down. What is the maximum altitude reached by the rocket?

Part 1

y_0	y	V_{oy}	V_y	a_y	t
0 m	?	0 m/s	?	15.50 m/s²	12.50 s

$$V_y = V_{oy} + a_y t \quad (V_{oy}=0) \rightarrow V_y = (15.50\,m/s^2)(12.50\,s) = 193.8\,m/s$$

$$y = y_0 + V_{oy}t + \tfrac{1}{2}a_y t^2 \quad (y_0=0,\ V_{oy}=0) \rightarrow y = \tfrac{1}{2}a_y t^2 = \tfrac{1}{2}(15.50\,m/s^2)(12.50\,s)^2$$

$$y = 1211\,m$$

Part 2

y_0	y	V_{oy}	V_y	a_y	t
1211 m	?	193.8 m/s	0 m/s	-9.80 m/s²	

$$V_y^2 = V_{oy}^2 + 2a_y(y - y_0) \quad (V_y=0) \rightarrow y = y_0 - V_{oy}^2/2a_y$$

$$y = 1211\,m - \frac{(193.8\,m/s)^2}{2(-9.80\,m/s^2)}$$

$$y = 3127\,m = 3.13 \times 10^3\,m$$

4) Two crates are sliding on a frictionless surface as shown in the figure below. The 10.0 kg crate is sliding to the right at 8.0 m/s and the 25 kg crate is sliding to the left at 5.5 m/s. After the collision, the two crates stick together. What is the speed of the two carts after the collision?

system → both crates ext. forces → $\vec{n} + \vec{w}$

$\Sigma F_{ext} = 0 \rightarrow \vec{P}_f = \vec{P}_i$

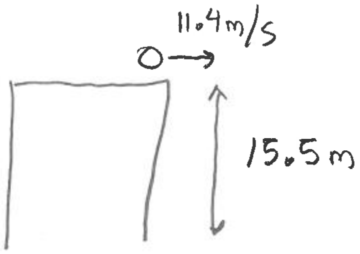
$$(m_1 + m_2)\vec{V}_f = m_1 \vec{V}_{1i} + m_2 \vec{V}_{2i}$$

$$\vec{V}_f = \frac{m_1 \vec{V}_{1i} + m_2 \vec{V}_{2i}}{(m_1 + m_2)}$$

$$\vec{V}_f = \frac{(10.0\,\text{Kg})(8.0\,\text{m/s}) + (25\,\text{Kg})(-5.50\,\text{m/s})}{10.0\,\text{Kg} + 25\,\text{Kg}}$$

$\vec{V}_f = -1.64$ m/s → **speed = 1.64 m/s**

5) A golf ball rolls off a horizontal cliff with an initial speed of 11.4 m/s. The ball falls a vertical distance of 15.5 m into a lake below. **(a)** How far from the edge of the cliff does the ball land? **(b)** What is the ball's velocity (magnitude and direction) right before it hits the lake?



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

$$y = y_o + V_{oy}t + \tfrac{1}{2}a_y t^2 \quad (y = 0,\ V_{oy} = 0)$$

$$t = \sqrt{\frac{-2y_o}{a_y}} = \sqrt{\frac{-2(15.5\,m)}{-9.80\,m/s^2}} \rightarrow t = 1.78\,s$$

X_o	X	V_{ox}	t
0 m	?	11.4 m/s	1.78 s

$$X = X_o + V_{ox}t \quad (X_o = 0)$$

$$X = (11.4\,m/s)(1.78\,s)$$

$$\boxed{X = 20.3\,m}$$

(b) $V_x = V_{ox} = 11.4\,m/s$

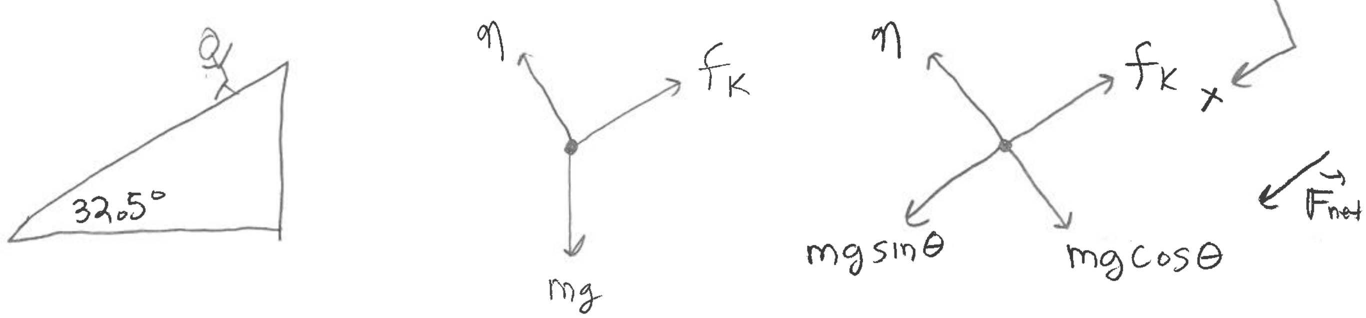
$$V_y = V_{oy} + a_y t \quad (V_{oy} = 0) \rightarrow V_y = (-9.80\,m/s^2)(1.78\,s)$$

$$V_y = -17.4\,m/s$$

$$V = \sqrt{V_x^2 + V_y^2} = \sqrt{(11.4\,m/s)^2 + (-17.4\,m/s)^2} \rightarrow \boxed{V = 20.8\,m/s}$$

$$\theta = \tan^{-1}\left(\frac{V_y}{V_x}\right) = \tan^{-1}\left(\frac{-17.4\,m/s}{11.4\,m/s}\right) \rightarrow \boxed{\theta = -56.8^\circ}$$

6) A 25 kg child goes down a long, straight slide inclined at an angle of 32.5° above the horizontal. The coefficient of kinetic friction between the child and the slide is $\mu_k = 0.35$. If the child starts from rest, how far down the slide does the she slide in 1.75 s?



$$\sum F_y = ma_y = 0$$

$$n - mg\cos\theta = 0 \rightarrow n = mg\cos\theta$$

$$\sum F_x = ma_x$$

$$mg\sin\theta - f_K = ma_x \qquad f_K = \mu_K n = \mu_K mg\cos\theta$$

$$mg\sin\theta - \mu_K mg\cos\theta = ma_x$$

$$a_x = g\sin\theta - \mu_K g\cos\theta$$

$$a_x = (9.80\,m/s^2)\sin 32.5° - (0.35)(9.80\,m/s^2)\cos 32.5°$$

$$a_x = 2.37\,m/s^2$$

X_0	X	V_{0x}	V_x	a_x	t
0 m	?	0 m/s		2.37 m/s²	1.75 s

$$X = \overset{=0}{X_0} + \overset{=0}{V_{0x}}t + \tfrac{1}{2}a_x t^2 \rightarrow X = \tfrac{1}{2}a_x t^2$$

$$X = \tfrac{1}{2}(2.37\,m/s^2)(1.75\,s)^2 \rightarrow \boxed{X = 3.63\,m}$$