Physics – Grade 9 – Advanced. AY: 2023 - 2024 . . . Term 2
End of Term 2 Questions and Answers.
Collected & prepared by: Abd – Alkareem Megdadi –abdalkareem.megdadi@ese.gov.ae
Science Department – Physics. AlResalah Primary and Secondary School – 542.
Abu Dhabi – AlFaqa'a – Ministry of Education – Emirates Schools Establishment.

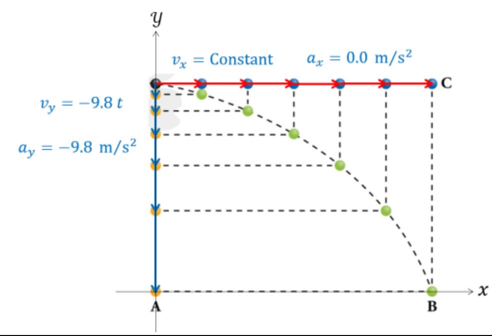
PART ONE – MULTIPLE CHOICE QUESTIONS

(LO:1) Explain the motion of horizontally launched projectiles and show schematically the components of velocity and acceleration throughout the motion. Example/Exercise: 7,8 – Page 147.

Horizontally Launched Projectiles.

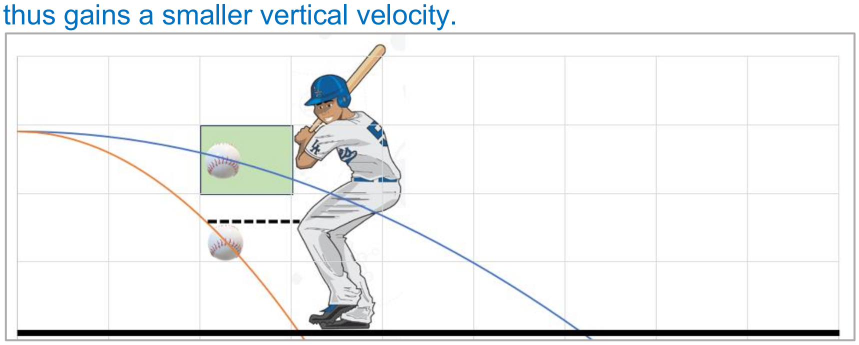
The object's horizontal velocity is not changing, and the object is not accelerating horizontally.

The object's vertical velocity is increasing, and the object is accelerating downward.

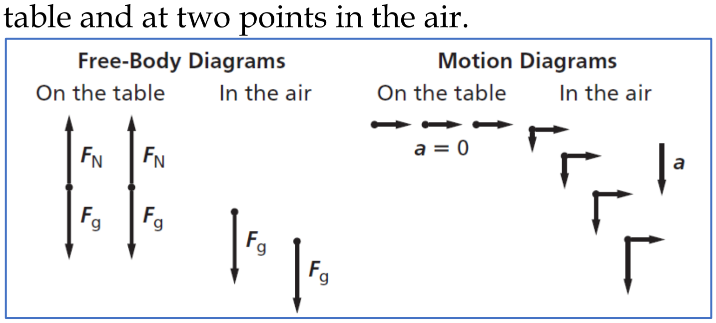


Ex. 7 Two baseballs are pitched horizontally from the same height but at different speeds. The faster ball crosses home plate within the strike zone, but the slower ball is below the batter's knees. Why do the balls pass the batter at different heights?

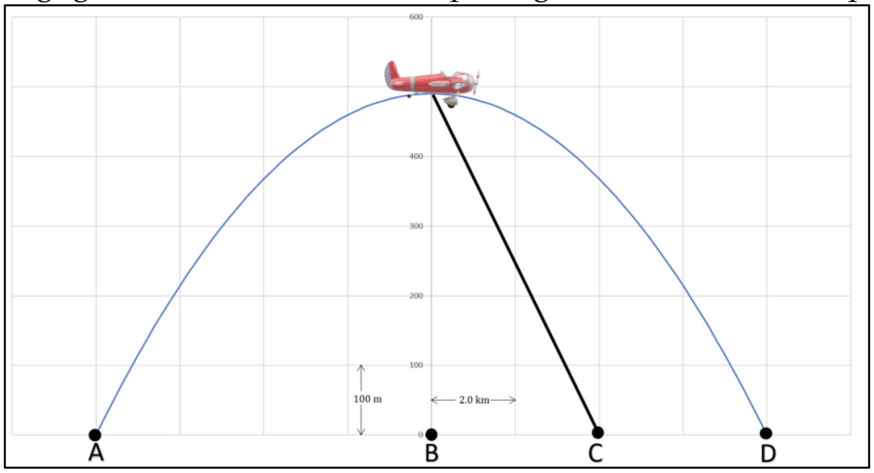
The faster ball travels horizontally faster than the slower one, so the faster ball is in the air a shorter time, and thus gains a smaller vertical velocity.



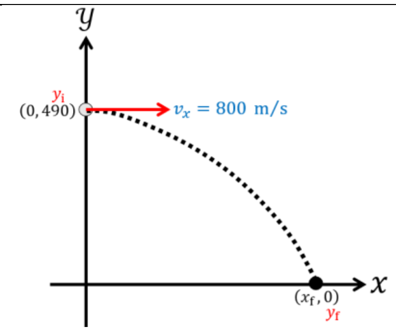
Ex. 8 An ice cube slides without friction across a table at a constant velocity. It slides off the table and lands on the floor. Draw free-body and motion diagrams of the ice cube at two points on the table and at two points in the air.



Problem. Suppose a rescue airplane drops a relief package while it is moving with a constant horizontal speed of 800 m/s at an elevated height of 490 m. Assuming that air resistance is negligible, where will the relief package land relative to the plane?



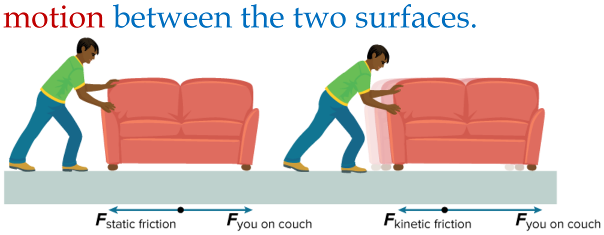
The package will fall at point D since the package will follow a horizontally launched projectile path.

$y_f = y_i + v_{yi}t + \frac{1}{2}a_y t^2$ $0.0 = 490 + 0 + \frac{1}{2}(-9.8)t^2$ SHIFT + SOLVE. $t = 10$ s $x_f = 800 \times t$ $x_f = 800 \times 10$ $x_f = 8000 = 8.0$ km		Quick way: $t = \sqrt{\frac{2h}{g}}$ $t = \sqrt{\frac{2 \times 490}{9.8}}$ $t = 10.0\ s$

(LO:2) Define the friction force as a type of force between two touching surfaces and determine its direction. Figure 10 – Page 122.

kinetic friction force $(F_{f_k} = \mu_k F_N)$ is the force exerted on one surface by another when the two surfaces rub against each other because one or both surfaces are moving.

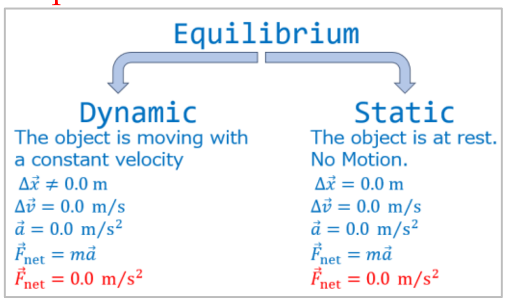
Static friction force $(F_{f_s} = \mu_s F_N)$ is the force exerted on one surface by another when there is no motion between the two surfaces.



Similarities	Differences
Always opposing the direction of motion. They both perpendicular to the normal force. They both are proportional to the normal force.	Static friction force (F_{f_s}) exist once any two objects are in contact with each other. Kinetic friction force (F_{f_k}) exist only once one object start sliding against other. $f_k \leq f_s$

(LO:3) Recall that for an object to be in equilibrium, the net force acting on it should be zero.
As mentioned in the book– Page128.

When the net force on an object is zero, the object is in equilibrium. According to Newton's laws, the object will not accelerate because there is no net force acting on it; an object in equilibrium moves with constant velocity. (Remember that staying at rest is a state of constant velocity.) Equilibrium can also occur if more than two forces act on an object. As long as the net force on the object is zero, the object is in equilibrium.



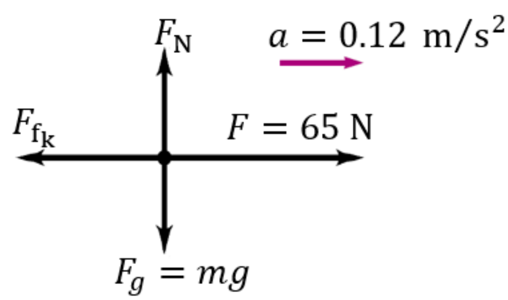
(LO:4) Solve problems related to friction. Exercise: 19,20 – Page: 127.

Ex. 19 You want to move a 41-kg bookcase to a different place in the living room. If you push with a force of 65 N and the bookcase accelerates at 0.12 m/s^2, what is the coefficient of kinetic friction between the bookcase and the carpet?

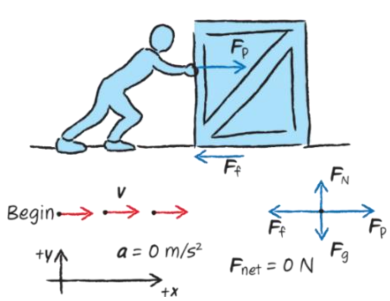
For a horizontal motion the normal force is equal to the weight: $F_{\text{N}} = m\,g$ So,

$F_{\text{f}_\text{k}} = \mu_\text{k}\,F_N$

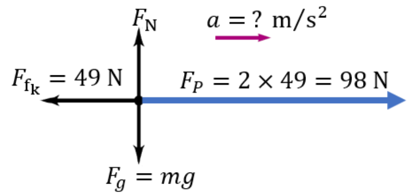
$F_{\text{f}_\text{k}} = \mu_\text{k}\,mg$

Apply Newton's 2nd Law: $F_{\text{net}} = m\,a$ $F - F_{\text{f}_\text{k}} = m\,a$ $F - \mu_k mg = m\,a$ $65 - (\mu_k \times 41 \times 9.8) = 41 \times 0.12$ $\mu_\text{k} = 0.15$	

Example 3, P 125.
You push a 25.0 kg wooden box across a wooden floor at a constant speed of 1.0 m/s. The coefficient of kinetic friction is 0.20. How large is the force that you exert on the box?

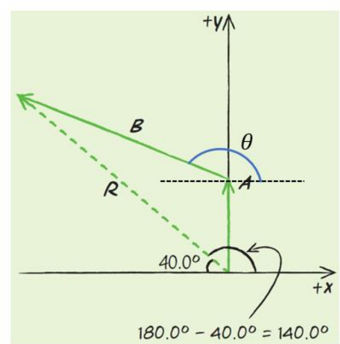
Diagram & Free – Body Diagram	Solution
	Vertically there is no acceleration: $F_N = F_g \Rightarrow F_N = m\,g$ Horizontally the speed is constant, so $a = 0.0$ m/s^2 Apply Newton's 2nd Law: $F_{net} = m\,a$ $F_P - F_f = m \times 0.0 \quad \Rightarrow F_P = F_f$ $F_P = \mu_k\,F_N \quad \Rightarrow F_P = \mu_k\,m\,g$ $F_P = 0.20 \times 25.0 \times 9.80$ $F_P = 49.0$ N

Example 4
Imagine that the force you exert on the 25.0-kg box in Example Problem 3 is doubled.
a. What is the resulting acceleration of the box?
b. How far will you push the box if you push it for 3 s?

$F_{net} = m\,a$ $98 - 49 = 25.0 \times a$ $a = 1.96\ \text{m/s}^2$	$x = \frac{1}{2}at^2 + v_i t + x_i$ $x = \frac{1}{2} \times 1.96 \times 3^2 + (1.0 \times 3.0) + 0.0$ $x = 11.82\ \text{m} \approx 12.0\ \text{m}$	

Ex. 20 Consider the force pushing the box in Example Problem 4. How long would it take for the velocity of the box to double to 2.0 m/s?
$v_f = at + v_i$
$2.0 = (1.96)t + 1.0$
$t = 0.5\ s$

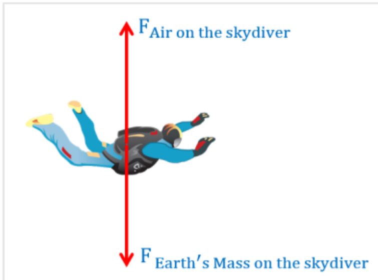
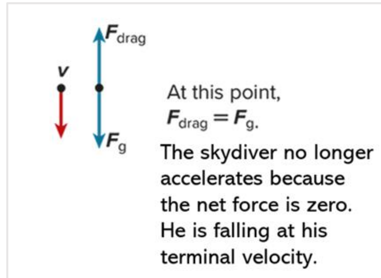
(LO:5) Determine the components of a vector in cartesian coordinate system using trigonometry.
Example 2 – Page 127.
You are on a hike. Your camp is 15.0 km away, in the direction 40.0° north of west. The only path through the woods leads directly north. If you follow the path 5.0 km before it opens into a field, how far, and in what direction, would you have to walk to reach your camp?

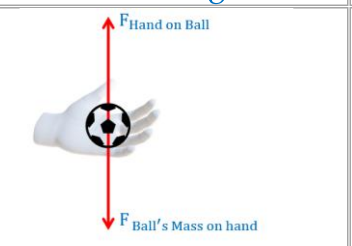
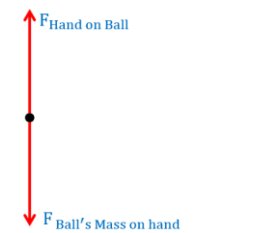
$\vec{R} = \vec{A} + \vec{B}$ $R_x = A_x + B_x$ $15\cos 140^\circ = A\cos 90^\circ + B\cos\theta$ $-11.5 = B\cos\theta$ $B = \frac{-11.5}{\cos\theta}$ $R_y = A_y + B_y$ $15\sin 140^\circ = A\sin 90^\circ + B\sin\theta$ $9.64 = 5 + B\sin\theta$	$9.64 = 5 + \left(\frac{-11.5}{\cos\theta}\right)\sin\theta$ $\theta = -22^\circ$ OR $\theta = -22^\circ + 180^\circ$ $\theta = 158^\circ$ $B = \frac{-11.5}{\cos 158^\circ}$ $B = 12.4$ km	

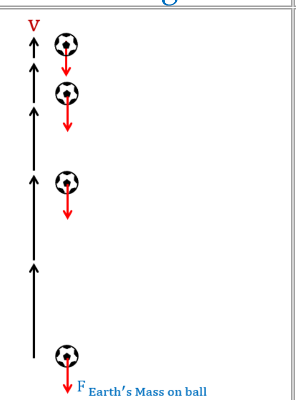
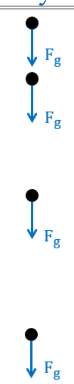
(LO:6) Use free body diagrams to compare the direction of an object's acceleration with the direction of the unbalanced force exerted on the object. Exercise: 1,2,3,4 – Page: 87.

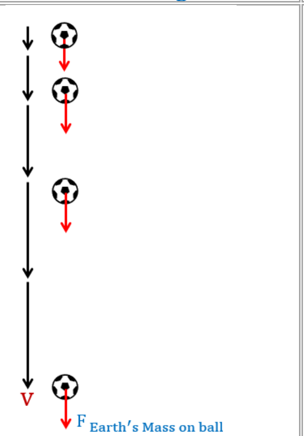
For each of the following situations, specify the system and draw a motion diagram and a free-body diagram. Label all forces with their agents and indicate the direction of the acceleration and of the net force. Draw vectors of appropriate lengths. Ignore air resistance unless otherwise indicated.

1. A skydiver falls downward through the air at constant velocity. (The air exerts an upward force on the person.)
2. You hold a softball in the palm of your hand and toss it up. Draw the diagrams while the ball is still touching your hand.
3. After the softball leaves your hand, it rises, slowing down.
4. After the softball reaches its maximum height, it falls down, speeding up.

[1]	Motion – Diagram.	Free – Body Diagram.	Note.
v = Constant, So $a = 0.0\ \mathrm{m/s^2}$ $F_{\text{net}} = m\,a$ $F_{\text{net}} = 0.0\ \text{N}$			F_{drag} and F_g do NOT represent action – reaction forces, because they are acting on the same object.

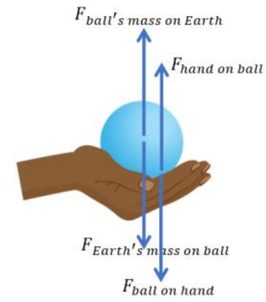
[2]	Motion – Diagram.	Free – Body Diagram.	Note.
$v = 0.0\ \mathrm{m/s}$ No motion. The ball is at rest.			$F_{\text{hand on ball}}$ and $F_{\text{ball's mass on hand}}$ represent action – reaction forces. $\boldsymbol{F}_{\text{A on B}} = -\boldsymbol{F}_{\text{B on A}}$

[3]	Motion – Diagram.	Free – Body Diagram.	Note.
The velocity is decreasing due to effect of the gravitational field which is always acting downward.			At the highest point, the ball will be, momentarily, at rest so it will reverse its direction of motion and falls downward.

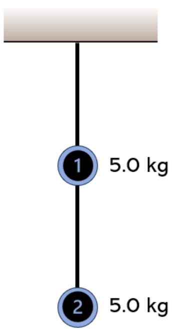
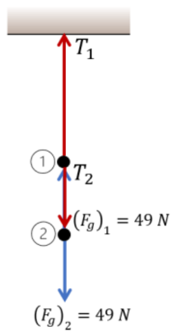
[4]	Motion – Diagram.	Free – Body Diagram.	Note.
The velocity is increasing due to effect of the gravitational field which is always acting downward.			The ball will reach the hand with the same initial velocity (v).

(LO:7) Combine forces to find the net force acting on an object.
Relate the direction of the acceleration to the direction of the net force. Exercises: 34,36,37 (P 105.)

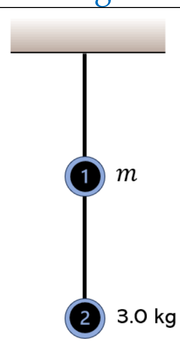
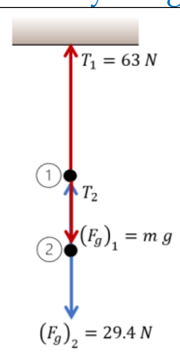
Ex. 34 Identify each force acting on the ball and its interaction pair in Figure 20.

 Figure 20	The forces on the ball are downward force of gravity due to the mass of Earth and the upward force of the hand. The force of the ball on Earth and the force of the ball on the hand are the other halves of the interaction pairs.	

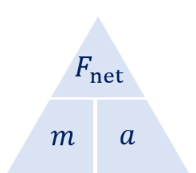
Ex. 36 A block hangs from the ceiling by a massless rope. A second block is attached to the first block and hangs below it on another piece of massless rope. If each of the two blocks has a mass of 5.0 kg, what is the tension in the rope?

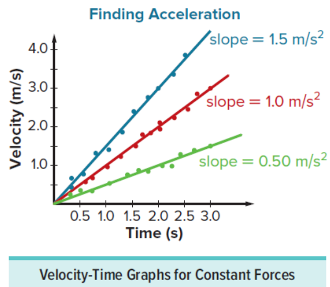
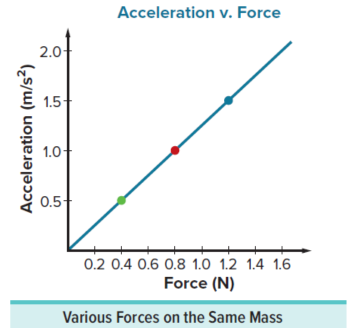
Diagram	Free – Body Diagram	Solution
		$T_1 = (F_g)_1 + (F_g)_2$ $T_1 = 49 + 49$ $T_1 = 98$ N $T_2 = (F_g)_2$ $T_2 = 49$ N

Ex. 37 A block hangs from the ceiling by a massless rope. A 3.0-kg block is attached to the first block and hangs below it on another piece of massless rope. The tension in the top rope is 63.0 N. Find the tension in the bottom rope and the mass of the top block.

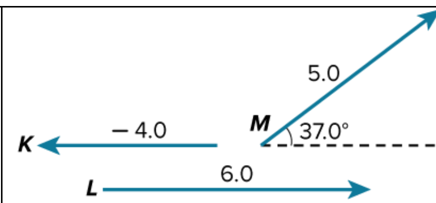
Diagram	Free – Body Diagram	Solution
		$T_2 = (F_g)_2$ $T_2 = 29.4\ N$ $T_1 = (F_g)_1 + (F_g)_2$ $63 = mg + 29.4$ $63 = m(9.8) + 29.4$ $m = 3.4\ kg$

(LO:8) Relate the direction of the acceleration to the direction of the net force. Figure 5 – Page 88.
The object will accelerate at the same direction where the net force acting on that object acts.

	$F_{net} = m\ a$ $m = \frac{F_{net}}{a}$ $a = \frac{F_{net}}{m}$

A spring scale pulling a low-resistance cart with a constant unbalanced force.	velocity-time graphs for constant forces	Acceleration – Force graph.
		
Gravity does not act horizontally. The force act on a smooth surface (well – polished table).	$a = \dfrac{\Delta v}{\Delta t}$	$\text{Slope} = \dfrac{\Delta a}{\Delta F} = \dfrac{1}{mass\ (m)}$ $1.25 = \dfrac{1}{m} \Longrightarrow m = 0.8\ \text{kg}$

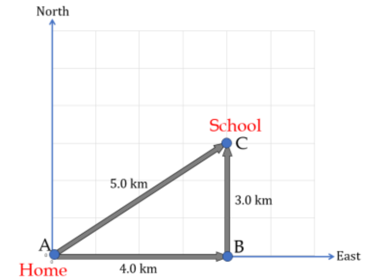
(LO:9) Resolve a vector into two orthogonal vectors in cartesian coordinate system.
Exercise: 11,12,13 – Page: 121.

Ex. 11 Use Figure 9 for these questions. a. Find the components of vectors K, L, and M. b. Find the sum of the three vectors. c. Subtract vector K from vector L.	 **Figure 9**

[a] $M_x = M\cos\theta = (5.0)\cos 37° = 4.0$ $M_y = M\sin\theta = (5.0)\sin 37° = 3.0$ $L_x = L\cos\theta = (6.0)\cos 0° = 6.0$ $L_y = L\sin\theta = (6.0)\sin 0° = 0.0$ $K_x = K\cos\theta = \lvert(-4.0)\rvert\cos 180° = -4.0\ N$ $K_y = K\sin\theta = (\lvert -4.0\rvert)\sin 180° = 0.0\ N$	[b] $R_x = M_x + L_x + K_x = 4.0 + 6.0 + (-4.0) = 6.0$ $R_y = M_y + L_y + K_y = 3.0 + 0.0 + (0.0) = 3.0$ $R = \sqrt{(R_x)^2 + (R_y)^2}$ $R = \sqrt{(6.0)^2 + (3.0)^2} = 6.7$ $\theta = \tan^{-1}\left(\dfrac{R_y}{R_x}\right)$ $\theta = \tan^{-1}\left(\dfrac{3.0}{6.0}\right) = 27^\circ$

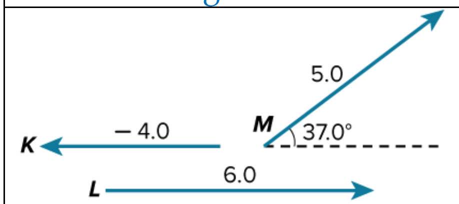
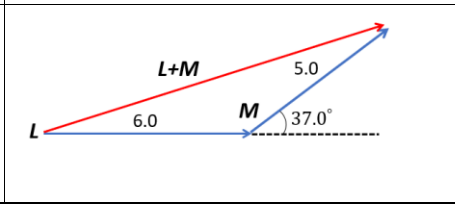
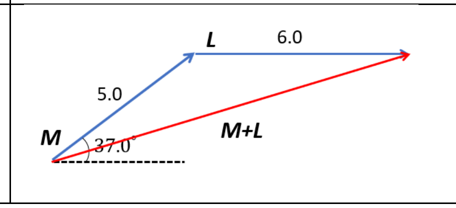
[c] $\boldsymbol{L} - \boldsymbol{K} = 6.0 - (-4.0) = 10.0$

Ex. 12 Are distance and displacement always the same? Give an example that supports your conclusion.
Not necessarily.
Moving from home to school along two different paths, ABC and AC.



Along the path ABC.	Along the path AC.
Distance = 4.0 km + 3.0 km Distance = 7.0 km Displacement $= \sqrt{(4.0)^2 + (3.0)^2}$ Displacement $= 5.0$ km	Distance = 5.0 km Displacement = 5.0 km

Ex. 13 a. Use the vectors from Figure 9 to show graphically that M + L = L + M.
b. Are addition, subtraction, multiplication, and division commutative? Give an example of each operation to support your conclusion.

Figure 9	$L + M$	$M + L$
		

Addition	Subtraction	Multiplication	Division
$\vec{A} + \vec{B} = \vec{B} + \vec{A}$	$\vec{A} - \vec{B} \neq \vec{B} - \vec{A}$	$\vec{A}.\vec{B} = \vec{B}.\vec{A}$ BUT $\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$	$\frac{\vec{A}}{\vec{B}}$ is undefined . $\frac{\vec{A}}{\text{scalar}}$ is possible

(LO:10) Relate graphically the frictional force to the normal force and find the coefficient of kinetic Friction. Figure 12 – Page 123.

Kinetic Friction Force

The kinetic friction force equals the product of the coefficient of kinetic friction and the normal force.

$$F_{\text{f, kinetic}} = \mu_k F_N$$

$$\mu_k = \frac{F_{\text{f,kinetic}}}{F_N}$$

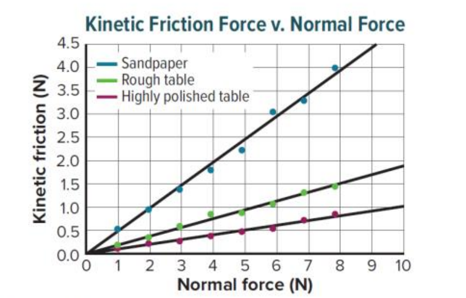
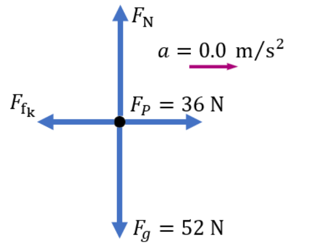


Figure 12 A plot of kinetic friction v. normal force for a block pulled along different surfaces shows a linear relationship between the two forces for each surface. The slope of the line is μ_k.

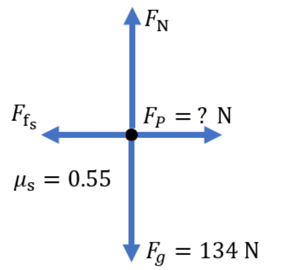
(LO:11) Apply the relationships that relate the normal force to maximum static friction and to kinetic friction to calculate unknown parameters like friction force, coefficient of friction or the normal force ($f_s = \mu_s F_N$) and ($f_k = \mu_k F_N$). Example 3, Questions 15, 16 – Page: 125.

Example 3, P 125… Go back to (LO:4)

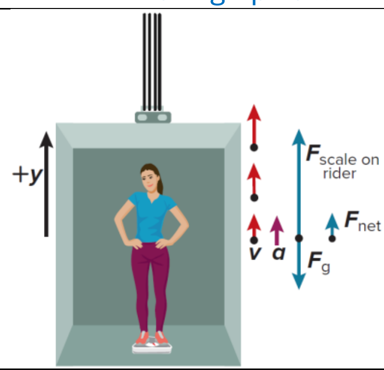
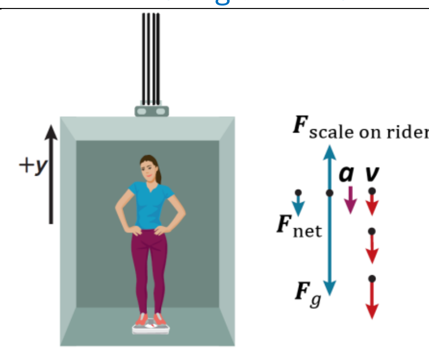
Ex. 15 Gwen exerts a 36-N horizontal force as she pulls a 52-N sled across a cement sidewalk at constant speed. What is the coefficient of kinetic friction between the sidewalk and the metal sled runners? Ignore air resistance.

$F_{f_k} = \mu_k F_N$ $36 = \mu_k \times 52$ $\mu_k = 0.69$	

Ex. 16 Mr. Ames is dragging a box full of books from his office to his car. The box and books together have a combined weight of 134 N. If the coefficient of static friction between the pavement and the box is 0.55, how hard must Mr. Ames push horizontally on the box in order to start it moving?

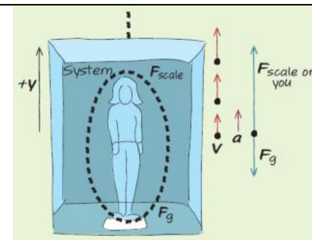
$F_{f_s} = \mu_s F_N$ $F_{f_s} = 0.55 \times 134$ $F_{f_s} = 73.7$ N $F_P = F_{f_s} = 73.7$ N $F_P = 74$ N	

(LO:12) Describe the apparent weight for an object accelerating vertically upward or downward (starts from rest, reaches a constant speed, then comes to a stop) Figure 11, Example 3 P 96, 97.

Accelerating upward.	Accelerating downward.
	
If you are accelerating upward, the net force acting on you must be upward. The scale must exert an upward force greater than the downward force of your weight. $F_{scale} = F_g + ma$	If you are accelerating downward, the net force acting on you must be downward. The scale must exert a downward force less than the downward force of your weight. $F_{scale} = F_g - ma$

Example 3, P 96

Your mass is 75.0 kg, and you are standing on a bathroom scale in an elevator. Starting from rest, the elevator accelerates upward at 2.00 m/s² for 2.00 s and then continues at a constant speed. Is the scale reading during acceleration greater than, equal to, or less than the scale reading when the elevator is at rest?

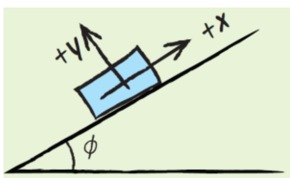
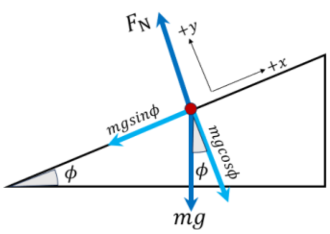
During the acceleration period.	When the elevator is at rest	
$F_{scale} = F_g + ma$ $F_{scale} = (75.0 \times 9.8) + (75.0 \times 2.0)$ $F_{scale} = 885$ N	$F_{scale} = F_g$ $F_{scale} = (75.0 \times 9.8)$ $F_{scale} = 735$ N	

The scale reading when the elevator is accelerating (885 N) is larger than when it is at rest (735 N).

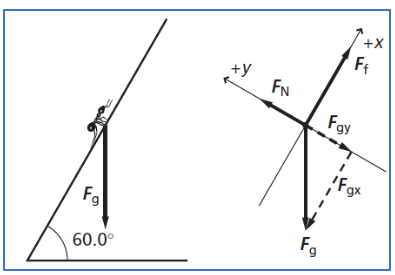
(LO:13) Apply Newton's Laws along x and y axes for an object that moves on an inclined plane with and without friction. Example 5, Questions 29, 31 – Page: 131.

Example 5, P 131

A 562-N crate is resting on a plane inclined 30.0° above the horizontal. Find the components of the crate's weight that are parallel and perpendicular to the plane.

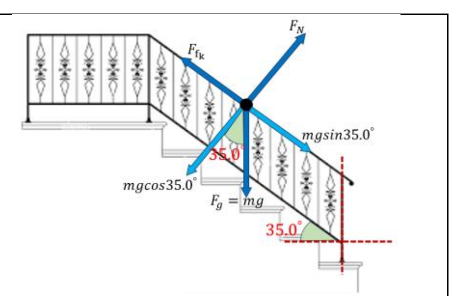
		$(F_g)_{\parallel} = -mgsin\phi$ $(F_g)_{\parallel} = -562\ sin30.0^{\circ}$ $(F_g)_{\parallel} = -281$ N $(F_g)_{\perp} = -mgcos\phi$ $(F_g)_{\perp} = -562\ cos30.0^{\circ}$ $(F_g)_{\perp} = -487$ N

Ex. 29, P 131 An ant climbs at a steady speed up the side of its anthill, which is inclined 30.0° from the vertical. Sketch a free-body diagram for the ant.



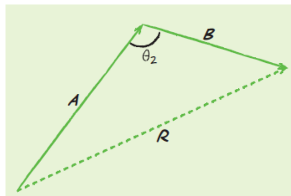
Ex. 31, P 131

Fernando, who has a mass of 43.0 kg, slides down the banister at his grandparents' house. If the banister makes an angle of 35.0° with the horizontal, what is the normal force between Fernando and the banister?

The normal force is equal to the perpendicular component of the weight. $F_N = (F_g)_{\perp}$ $F_N = mgcos30.0^{\circ}$ $F_N = 43.0 \times 9.8 \times cos35.0^{\circ}$ $F_N = 345$ N	

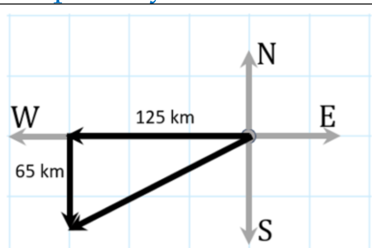
(LO:14) Determine the magnitude and direction of the resultant of two vectors in two dimensions using trigonometry, the Pythagorean theorem (case of perpendicular vectors), and the laws of sines and cosines. Example 1, Questions 1, 2 – Page: 116.

Example 1 P 116 Find the magnitude of the sum of a 15-km displacement and a 25-km displacement when the angle θ between them is 90° and when the angle θ between them is 135°.

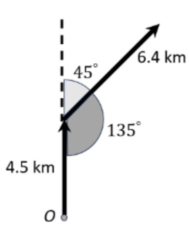
Apply the cosine law: $R = \sqrt{A^2 + B^2 - 2AB\cos\theta}$	

$\theta = 90^\circ$	$\theta = 135^\circ$
$R = \sqrt{15^2 + 25^2 - (2 \times 15 \times 25 \times \cos 90^\circ)}$ $R = 29$ km	$R = \sqrt{15^2 + 25^2 - (2 \times 15 \times 25 \times \cos 135^\circ)}$ $R = 37$ km

Ex. 1, P 116 You and your family are out for a drive. You drive 125.0 km due west, then turn due south and drive for another 65.0 km. What is the magnitude of your displacement? Solve this problem both graphically and mathematically and check your answers against each other.

Graphically	Mathematically
	$R = \sqrt{A^2 + B^2}$ $R = \sqrt{125^2 + 65^2}$ $R = 141$ km

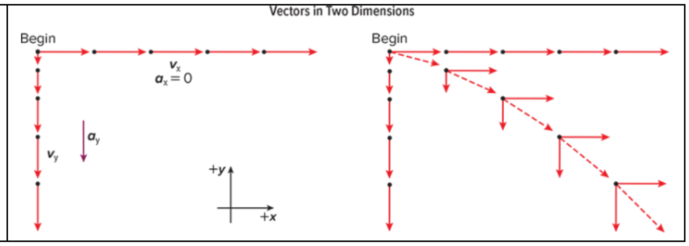
Ex. 2, P 116 On a fine, sunny day, you and your siblings decide to go for a nearby hike. You walk 4.5 km in one direction, then make a 45° turn to the right and walk another 6.4 km. What is the magnitude of your displacement?

Graphically	Mathematically
	$R = \sqrt{4.5^2 + 6.4^2 - (2 \times 4.5 \times 6.4 \times \cos 135^\circ)}$ $R = 10$ km

(LO:15) Explain the motion of horizontally launched projectiles and show schematically the components of velocity and acceleration. Figures 2,3 – Pages 141, 142.

Figure 2: The ball on the left was dropped with no initial velocity. The ball on the right was given an initial horizontal velocity. The balls have the **same** vertical motion as they fall.

Figure 3: To describe the motion of a horizontally launched projectile, the x- and y-components can be treated independently. The resultant vectors of the projectile are tangent to a parabola.



	Along x – axis	Along y – axis
Velocity	$v_x =$ constant	$v_y = -9.8\,t + v_i \sin\theta$
Acceleration	$a_x = 0$	$a_y = -9.80\ \text{m/s}^2$

PART TWO – WRITTEN PART.

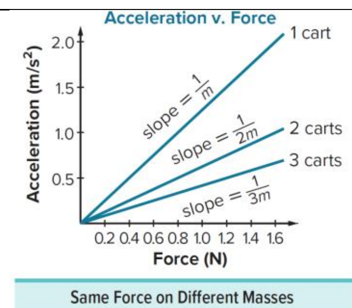
(LO:16) Demonstrate by experiments that acceleration of an object is directly proportional to the force applied and inversely proportional to the mass of the object.

State Newton's second law of motion and write it in equation form ($a = \frac{F_{net}}{m}$).

As mentioned in the book– Page90.

Figure 6 Changing an object's mass affects that object's acceleration.

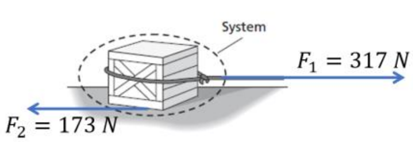
$$a = \left(\frac{1}{m}\right) F_{net}$$



Question [1]: Two horizontal forces are exerted on a large crate. The first force is 317 N to the right. The second force is 173 N to the left.

a. Draw a force diagram for the horizontal forces acting on the crate.

b. What is the net force acting on the crate?

[a] Force Diagram	[b] The net force.
	$F_{net} = F_1 - F_2$ $F_{net} = 317 - 173$ $F_{net} = 144$ N to the right.

Question [2]: Joyce and Efua are skating. Joyce pushes Efua, whose mass is 40.0 kg, with a force of 5.00 N. What is Efua's resulting acceleration?

$$a = \frac{F_{\text{net}}}{m}$$

$$a = \frac{5.00}{40.0}$$

$$a = 0.125\ \text{m/s}^2$$

Question [3]: A 2300-kg car slows down at a rate of 3.0 m/s^2 when approaching a stop sign. What is the magnitude of the net force causing it to slow down?

$$F_{\text{net}} = m\,a$$

$$F_{\text{net}} = (2300)(3.0)$$

$$F_{\text{net}} = 6900\ \text{N}$$

Question [3]: After Thanksgiving, Kevin and Gamal use the turkey's wishbone to make a wish. If Kevin pulls on it with a force 0.17 N larger than the force Gamal pulls with in the opposite direction and the wishbone has a mass of 13 g, what is the wishbone's initial acceleration?

$$a = \frac{F_{\text{net}}}{m}$$

$$a = \frac{0.17}{0.013} \quad \Longrightarrow \quad a = 13\ \text{m/s}^2$$

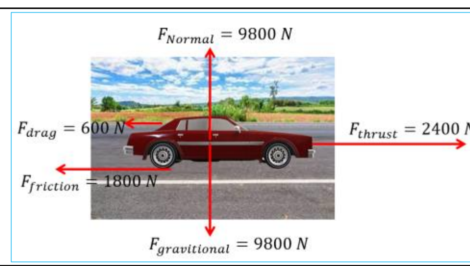
Question [4]: What is the net force acting on a 1.0-kg ball moving at a constant velocity?
Constant velocity means $a = 0.0\ \text{m/s}^2$

$$F_{\text{net}} = m\,a$$

$$F_{\text{net}} = (1.0)(0.0)$$

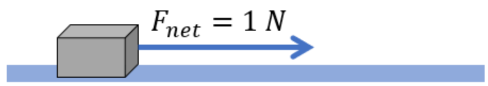
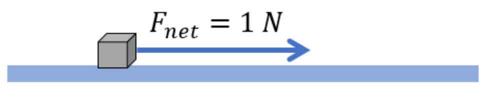
$$F_{\text{net}} = 0.0\ \text{N}$$

Question [5]: Suppose that the acceleration of an object is zero. Does this mean that there are no forces acting on the object? Give an example using an everyday situation to support your answer.

<table>
<tr>
<td>$F_{\text{net}} = m\,a$
$F_{\text{net}} = (m)(0.0)$
$F_{\text{net}} = 0.0\ \text{N}$</td>
<td>A car travelling at a constant velocity. The net forces acting on that car equals zero, but this does not mean that there are no forces acting on it.</td>
<td>
</td>
</tr>
</table>

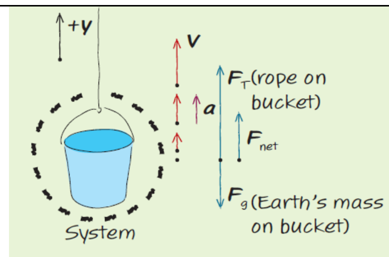
Question [6]: A force of 1 N is the only horizontal force exerted on a block, and the horizontal acceleration of the block is measured. When the same horizontal force is the only force exerted on a second block, the horizontal acceleration is three times as large. What can you conclude about the masses of the two blocks?

Because $m = \frac{F_{net}}{a}$ and the forces are the same, the mass of the second block is one-third the mass of the first block.

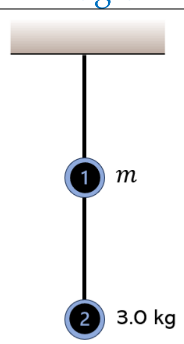
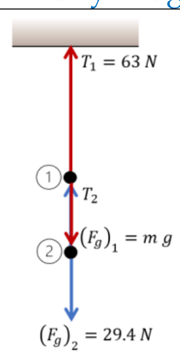
	Diagrams	Newton's 2nd Law.	
①		$a_1 = \frac{F_{\text{net}}}{m_1} \Rightarrow a_1 = \frac{1}{m_1}$	Given that: $a_2 = 3\,a_1$ $\frac{1}{m_2} = 3 \times \frac{1}{m_1}$ $m_2 = \frac{1}{3}\,m_1$
②		$a_2 = \frac{F_{\text{net}}}{m_2} \Rightarrow a_2 = \frac{1}{m_2}$	

(LO:17) Apply Newton's Second Law to solve numerical problems. Exercise: 33,37 – Page: 133.

Ex. 33 You are loading equipment into a bucket that roofers will hoist to a rooftop. If the rope will not break as long as the tension does not exceed 450 N and you fill the bucket until it has a mass of 42 kg, what is the greatest acceleration the workers can give the bucket as they hoist it?

Apply Newton's 2nd Law. $F_{\text{net}} = ma$ $F_{\text{T}} - F_g = ma$ $450 - (42 \times 9.8) = 42 \times a$ $a = 0.91\ \text{m}/s^2$	

Ex. 37 A block hangs from the ceiling by a massless rope. A 3.0-kg block is attached to the first block and hangs below it on another piece of massless rope. The tension in the top rope is 63.0 N. Find the tension in the bottom rope and the mass of the top block.

Diagram	Free – Body Diagram	Solution
		$T_2 = (F_g)_2$ $T_2 = 29.4\ N$ $T_1 = (F_g)_1 + (F_g)_2$ $63 = mg + 29.4$ $63 = m(9.8) + 29.4$ $m = 3.4\ kg$

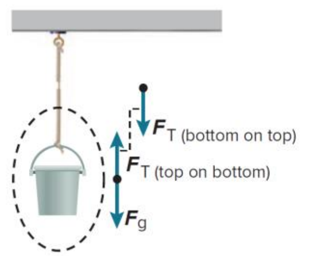
(LO:18) List the characteristics of the interaction pair and identify the action-reaction pairs for different situations. Figures 17,18 – Page 103.

Newton's third law.

The two forces in an interaction pair act on different objects and are equal in magnitude and opposite in direction and they both belong to the same type of forces.

$\vec{F}_{A \text{ on } B} = -\vec{F}_{B \text{ on } A}$

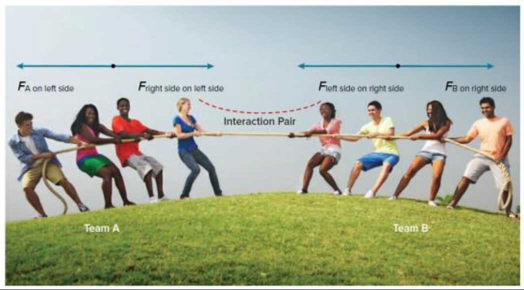
Figure 17 The tension in the rope is equal to the weight of all the objects hanging from it.



$F_{T\text{ (bottom on top)}}$ and $F_{T\text{ (top on bottom)}}$ represent an action – reaction pair of forces.

While F_T and F_g do NOT

Figure 18 The rope is not accelerating, so the tension in the rope equals the force with which each team pulls.



$F_{\text{right side on left side}}$ and $F_{\text{left side on right side}}$ represent an action – reaction pair of forces.

While $F_{A\text{ on left side}}$ and $F_{B\text{ on right side}}$ do NOT

(LO:19) Apply Newton's laws to solve problems involving normal and tension forces including systems of objects connected by strings and Atwood's machine.

Recall that for an object to be in equilibrium, the net force acting on it should be zero.

Example 5 – Page: 104.

Example 5, P 104

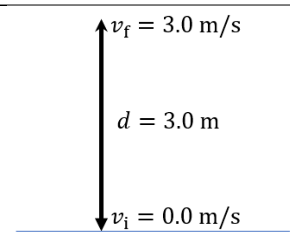
A 50.0-kg bucket is being lifted by a rope. The rope will not break if the tension is 525 N or less. The bucket started at rest, and after being lifted 3.0 m, it moves at 3.0 m/s. If the acceleration is constant, is the rope in danger of breaking?

Apply the time independent equation of motion.

$v_f^2 = v_i^2 + 2ad$

$3.0^2 = 0.0^2 + 2 \times a \times 3.0$

$a = 1.5 \text{ m/s}^2$



Apply Newton's 2nd Law.

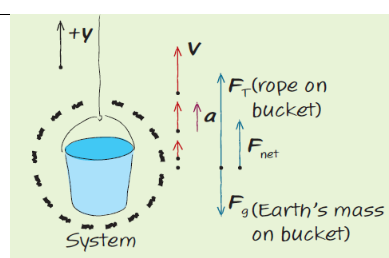
$F_{net} = ma$

$F_T - F_g = ma$

$F_T = mg + ma$

$F_T = (50.0 \times 9.8) + (50.0 \times 1.5)$

$F_T = 565$ N



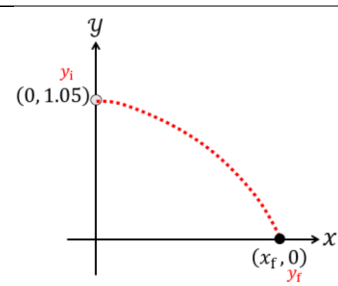
The rope is in danger of breaking because the tension exceeds 525 N.

Problem. An 873-kg dragster, starting from rest, attains a speed of 26.3 m/s in 0.590 s.
a. Find the average acceleration of the dragster.
b. What is the magnitude of the average net force on the dragster during this time?
c. What horizontal force does the seat exert on the driver if the driver has a mass of 68.0 kg?

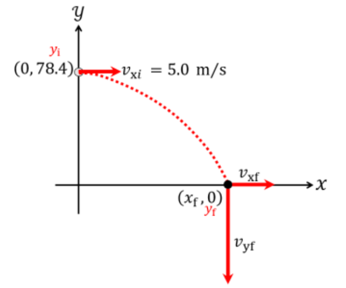
[a]	[b]	[c]
$a = \frac{\Delta v}{\Delta t}$ $a = \frac{26.3 - 0.0}{0.590}$ $a = 44.6\ \text{m/s}^2$	$F_{\text{net}} = m\, a$ $F_{\text{net}} = 873 \times 44.6$ $F_{\text{net}} = 38915.08475\ \text{N}$ $F_{\text{net}} \approx 38900\ \text{N}$	$F_{\text{net}} = m\, a$ $F_{\text{net}} = 68.0 \times 44.6$ $F_{\text{net}} = 3030\ \text{N}$

(LO:20) Explain the motion of projectiles launched at an angle with the horizontal and show schematically the components of velocity and acceleration throughout the motion.
Example 1 & Q 1,2 – Page: 144.

Example 5, P 104
You are preparing breakfast and slide a plate on the countertop. Unfortunately, you slide it too fast, and it flies off the end of the countertop. If the countertop is 1.05 m above the floor and the plate leaves the top at 0.74 m/s, how long does it take to fall, and how far from the end of the counter does it land?

$y_f = y_i + v_{yi}t + \frac{1}{2} a_y t^2$ $0.0 = 1.05 + 0 + \frac{1}{2}(-9.8)\, t^2$ SHIFT + SOLVE. $t = 0.46\ \text{s}$ $x_f = v_x\, t$ $x_f = 0.74 \times 0.46$ $x_f = 0.34\ \text{m}$	 	Quick way: $t = \sqrt{\frac{2h}{g}}$ $t = \sqrt{\frac{2 \times 1.05}{9.8}} = 0.46\ \text{s}$

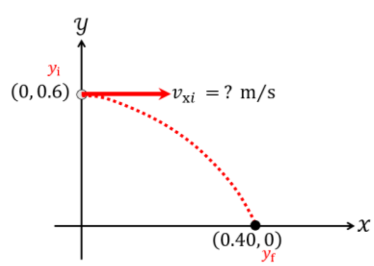
Ex. 1, P 144 A block You throw a stone horizontally at a speed of 5.0 m/s from the top of a cliff that is 78.4 m high.
a. How long does it take the stone to reach the bottom of the cliff?
b. How far from the base of the cliff does the stone hit the ground?
c. What are the horizontal and vertical components of the stone's velocity just before it hits the

[a]	$y_f = y_i + v_{yi}t + \frac{1}{2} a_y t^2$ $0.0 = 78.4 + 0 + \frac{1}{2}(-9.8)t^2$ SHIFT + SOLVE. $t = 4.0$ s		Quick way: $t = \sqrt{\frac{2h}{g}}$ $t = \sqrt{\frac{2 \times 78.4}{9.8}}$ $t = 4.0$ s

[b]	$x_f = v_x t$ $x_f = 5.0 \times 4.0$ $x_f = 20.0$ m

[c]	$v_{xf} = 5.0$ m/s	$v_{yf} = -g\,t + v_{yi}$ $v_{yf} = (-9.8 \times 4.0) + 0.0$ $v_{yf} = -39.2$ m/s

Ex. 2, P 144 Lucy and her friend are working at an assembly plant making wooden toy giraffes. At the end of the line, the giraffes go horizontally off the edge of a conveyor belt and fall into a box below. If the box is 0.60 m below the level of the conveyor belt and 0.40 m away from it, what must be the horizontal velocity of giraffes as they leave the conveyor belt?

$y_f = y_i + v_{yi}t + \frac{1}{2} a_y t^2$ $0.0 = 0.60 + 0 + \frac{1}{2}(-9.8)t^2$ SHIFT + SOLVE. $t = 0.35$ s $x_f = v_{xi}\, t$ $0.40 = v_x \times 0.35$ $v_{xi} = 1.1$ m/s		Quick way: $t = \sqrt{\frac{2h}{g}}$ $t = \sqrt{\frac{2 \times 0.6}{9.8}}$ $t = 0.35$ s

The end