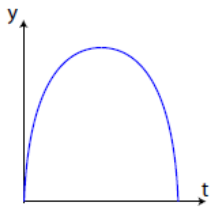
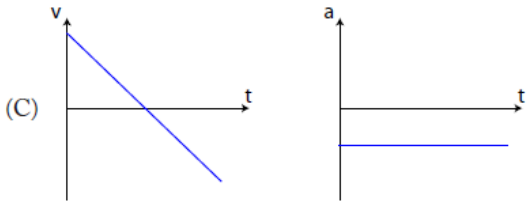
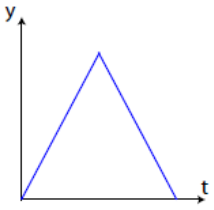
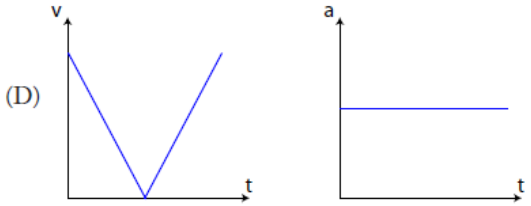
1. A ball is thrown vertically upward from the ground. Which pair of graphs best describes the motion of the ball as a function of time while it is in the air? Neglect air resistance.

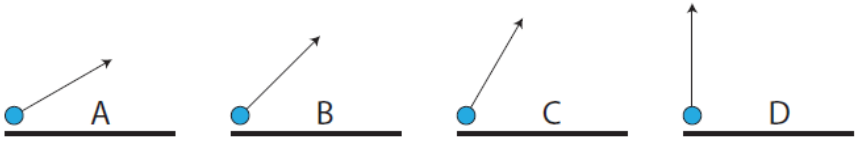
(A) 

(C) 

(B) 

(D) 

2. The following projectiles are launched on horizontal ground with the same initial speed. If two or three situations have the same answer, put the letters in the same blank space. Air resistance is negligible.



(a) Rank the situations from least to greatest in terms of time the projectile is in the air.
Least 1_____ 2_____ 3_____ 4_____ Greatest

Or, all of the projectiles are the same _____

(b) Rank the situations from least to greatest in terms of the horizontal distance the projectile travels while in the air.
Least 1_____ 2_____ 3_____ 4_____ Greatest

Or, all of the projectiles are the same _____

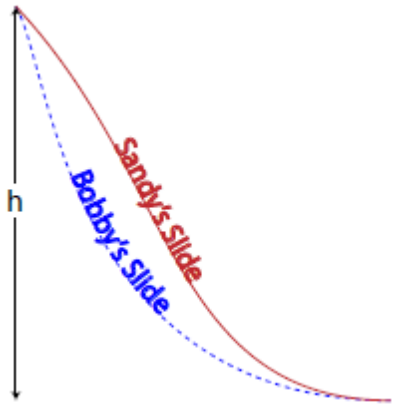
(c) Rank the situations from least to greatest in terms of the vertical distance the projectile travels while in the air.
Least 1_____ 2_____ 3_____ 4_____ Greatest

Or, all of the projectiles are the same _____

(d) Rank the situations from least to greatest in terms of the acceleration of the projectile while it is in the air.
Least 1_____ 2_____ 3_____ 4_____ Greatest

Or, all of the projectiles are the same _____

3. Two children on the playground, Bobby and Sandy, travel down slides of identical height h but different shapes as shown at right. The slides are frictionless. Assuming they start down the slides at the same time with zero initial velocity, which of the following statements is true?



(A) Bobby reaches the bottom first with the same average velocity as Sandy.
(B) Bobby reaches the bottom first with a larger average acceleration than Sandy.
(C) Bobby reaches the bottom first with the same average acceleration as Sandy.
(D) They reach the bottom at the same time with the same average acceleration.

4. You are asked to experimentally determine the acceleration of a skier traveling down a snow-covered hill of uniform slope as accurately as possible. Which combination of equipment and equation would be most useful in your endeavor?

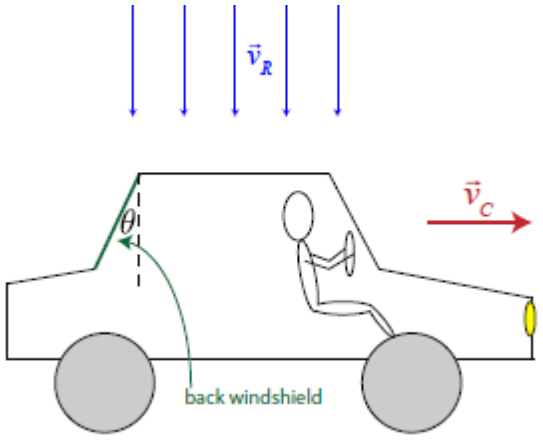
	equipment	**equation**
(A)	tape measure, stopwatch	$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$
(B)	photo gates, stopwatch	$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$
(C)	radar gun, tape measure	$v_x = v_{x0} + a_x t$
(D)	photo gates, radar gun	$\overline{v}_x = \frac{v_{0x} + v_x}{2}$

5. An eagle flies at constant velocity horizontally across the sky, carrying a turtle in its talons. The eagle releases the turtle while in flight. From the eagle's perspective, the turtle falls vertically with speed v_1. From an observer on the ground's perspective, at a particular instant the turtle falls at an angle with speed v_2. What is the speed of the eagle with respect to an observer on the ground?

(A) $v_1 + v_2$ (B) $v_1 - v_2$

(C) $\sqrt{v_1^2 - v_2^2}$ (D) $\sqrt{v_2^2 - v_1^2}$

6. A car travels through a rainstorm at constant speed V_C as shown in the diagram at right. Rain is falling vertically at a constant speed V_R with respect to the ground. If the back windshield of the car, highlighted in the diagram, is set at an angle of θ with the vertical, what is the maximum speed the car can travel and still have rain hit the back windshield?



(A) $v_R \cos\theta$ (B) $v_R \tan\theta$

(C) $v_R \sin\theta$ (D) $v_R(1-\sin\theta)$

7. A cargo plane flies horizontally at a speed of 140 m/s at a height of 50 m above the ground. A supply package is dropped out of the bottom of the plane at time t=0. Two seconds later, a second package is dropped out of the bottom of the plane. Air resistance is negligible.
What happens to the separation between the packages as they fall through the air?

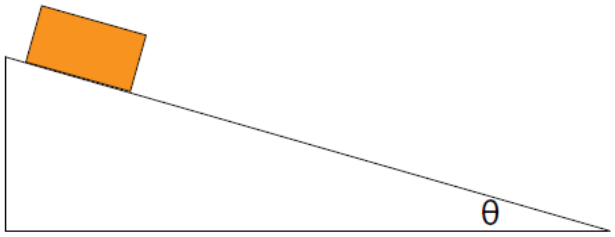
(A) The separation between packages decreases.
(B) The separation between packages increases.
(C) The separation between packages remains the same.
(D) Cannot answer without knowing the mass of the packages.

8. A cargo plane flies horizontally at a speed of 140 m/s at a height of 50 m above the ground. A supply package is dropped out of the bottom of the plane at time t=0. Two seconds later, a second package is dropped out of the bottom of the plane. Air resistance is negligible.
How far apart will the packages land on the ground?

(A) 70 m
(B) 140 m
(C) 280 m
(D) 420 m

9. An object slides one meter down a frictionless ramp of constant slope as shown at right (not to scale). A student measures the time it takes for the object to travel various displacements using a stopwatch. Three consecutive trials are measured, and the data is recorded as shown below.
Determine the acceleration of the object.

Displacement (m)	Avg. Time (s)
0	0
0.2	0.68
0.4	0.98
0.6	1.18
0.8	1.38
1	1.52



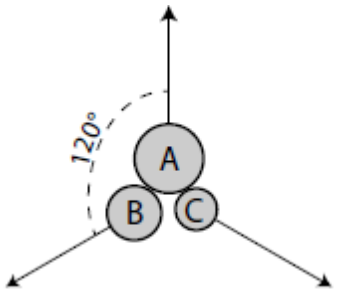
Determine the acceleration of the object.

10. Using the same schematic and data in problem 9, determine the angle Θ of the ramp.

11. A pirate captain in her ship spies her first mate in a dinghy five kilometers away. The pirate captain sails her ship toward the dinghy at a rate of eight kilometers per hour. The first mate rows his dinghy toward the pirate ship at a rate of two kilometers per hour. When the captain initially spies the first mate at a distance of five kilometers, her parrot, Polly, begins flying back and forth between the two at a rate of 40 kilometers per hour. How far does Polly fly in total if she continues her back-and-forth journey until the pirate ship meets the dinghy?

12. A train travels east toward Chicago at 80 km/hr. A man on the train runs from the front of the train toward the rear of the train at 10 km/hr. As he runs, he carries a plate of fruit with him. He notices a giant spider on the plate and throws the plate away from him (toward the rear of the train) at 20 km/hr. The startled spider jumps toward the man at 5 km/hr. The instant after the spider jumps toward the man, how fast is the spider approaching Chicago?

13. Three penguins are arranged in the center of a patch of frictionless ice floating across the ocean with a velocity of 2 m/s west. The mass of penguin A is 38 kg, the mass of penguin B is 30 kg, and the mass of penguin C is 23 kg. At time t=0, the penguins push off each other, each with a force of 20 newtons, such that they all slide away from the center of the floating ice patch at an angle of 120° from each other as shown in the diagram at right. Describe the motion of the center of mass of the three-penguin system at time t=3s.



14. A fisherman in a small fishing boat at rest in a lake hooks a giant log floating in the lake 30 meters away. The fisherman reels the log in. During this process, the boat moves 12 meters in the direction of the log. If the mass of the boat and fisherman is 400 kg, what is the mass of the log? Assume frictionless.

15. Two balls are launched off the edge a cliff of height h with an initial velocity v_0. The red ball is launched horizontally. The green ball is launched at an angle of θ above the horizontal. Neglect air resistance.

(a) Derive an expression for the time the red ball is in the air.

(b) Derive an expression for the horizontal distance traveled by the red ball while it is in the air.

(c) Derive an expression for the time the green ball is in the air.

(d) Derive an expression for the horizontal distance traveled by the green while while it is in the air.

(e) If the initial launch velocity v_0 of the balls is 100 m/s, the green ball is launched at an angle $\theta=30°$, and the balls land 600 meters apart from each other, what is the height of the cliff? (*Note: calculator use strongly encouraged for this step*).