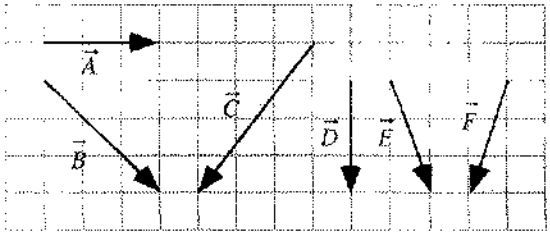
– Answer Key –

(1)

A2-RT10: Vectors on Grid V—Components of Vectors

Shown below are vectors superimposed on a grid.



(a) Rank the magnitudes of the *x*-components of each vector.

1 Greatest	2	3	4	5	6 Least	OR	All the same	All zero	Cannot determine
☐	☐	☐	☐	☐	☐		☐	☐	☐

Explain your reasoning.

Answer: $A = B = C > E = F > D$

Taking the x direction to be horizontal we are looking at the lengths, without regard for direction, of those components of the vectors. B and C both are three the same as A, E and F each have a one length horizontal component and D has a zero horizontal component.

(b) Rank the magnitudes of the *y*-components of each vector.

1 Greatest	2	3	4	5	6 Least	OR	All the same	All zero	Cannot determine
☐	☐	☐	☐	☐	☐		☐	☐	☐

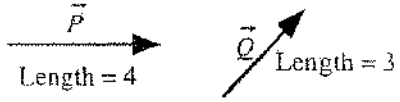
Explain your reasoning.

Answer: $C > B = D = E = F > A$

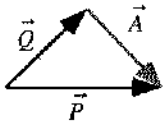
This time we are a looking at the vertical component lengths. C is four, B, D, E and F are all three, and A is zero.

(2) **A2-WWT11: Addition and Subtraction of Two Vectors—Direction of Resultant**

Two vectors, labeled $\vec{P}$ and $\vec{Q}$, are shown below. The length (magnitude) of each vector is given in arbitrary units.

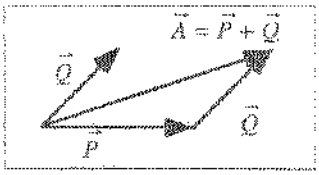


A student constructs the figure shown below to figure out the sum of the vectors $\vec{P}$ and $\vec{Q}$. The student contends that the lighter arrow $\vec{A}$ represents the vector sum of the vectors $\vec{P}$ and $\vec{Q}$.



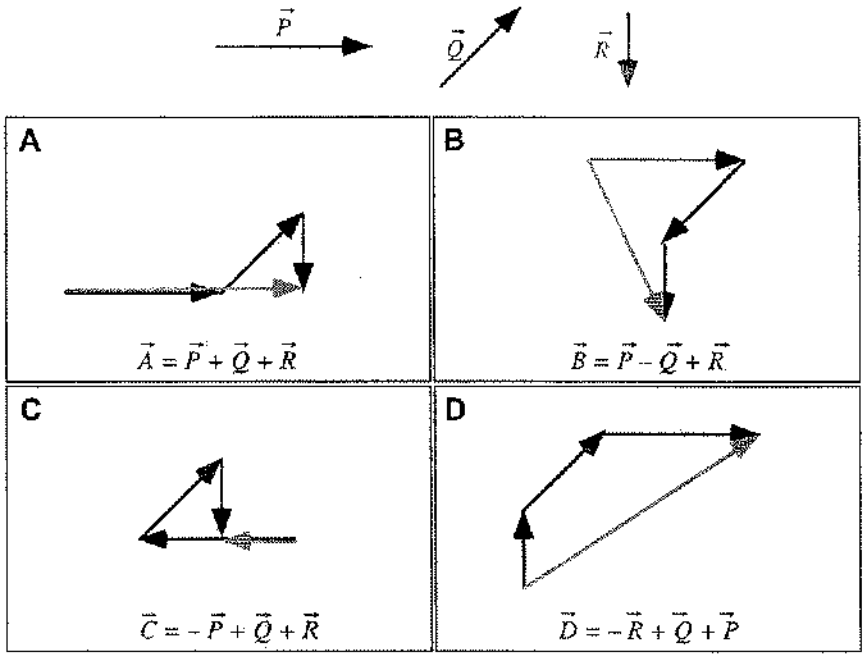
What, if anything, is wrong with the student's work? If something is wrong, identify it, and explain how to correct it. If his/her work is correct, explain why.

Answer: The vector A that the student constructed is equal to vector P– Q, not to P + Q. To add P and Q we need to put the tail of one of them at the head of the other as shown below.



(3) A2-RT22: Addition and Subtraction of Three Vectors—Direction of Resultant

Three vectors, labeled $\vec{F}$, $\vec{Q}$, and $\vec{R}$, are shown below.



In each space provided above, construct a drawing of the indicated combination of the vectors $\vec{F}$, $\vec{Q}$, and $\vec{R}$, and then rank the magnitude of the angle that the resultant vector makes with the vector $\vec{F}$.

				OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

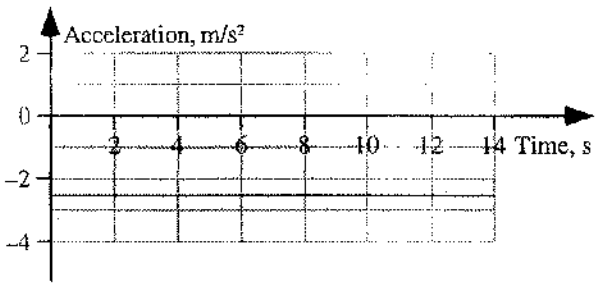
Explain your reasoning.

Answer: $C > B > D > A$.

From the vector constructions, we see that C points 180° away from P, and so the angle is largest, followed by B, which is less than 90° from P but greater than C. A is parallel to P, so we obtain the ranking $C > B > D > A$.

(4) **B1-WWT41: Acceleration-Time Graph—Interpretation**

A student is given the following acceleration versus time graph for a motorcyclist traveling along a straight, level stretch of road.



The student states:

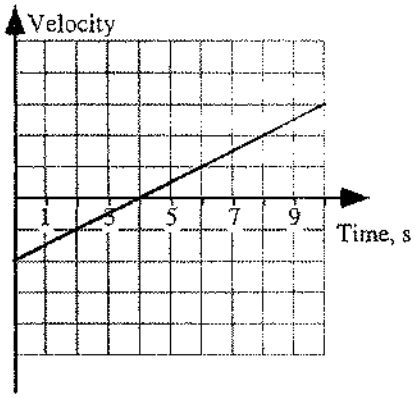
"This motorcyclist was slowing down during the period up to 14 seconds because her acceleration was negative during this period."

What, if anything, is wrong with this student's contention? If something is wrong, identify it and explain how to correct it. If it is correct, explain why.

Answer: This contention is problematic because the student doesn't know whether the motorcyclist's initial velocity was positive or negative. If the cyclist started out with an initial negative velocity then her speed was increasing, not decreasing, during the interval shown.

(5) **B1-QRT34: VELOCITY-TIME GRAPH—DIRECTION**

A unicyclist, someone riding a single-wheel cycle, is moving along a straight street oriented east—west. In drawing the graph, east was taken as the positive direction and west the negative direction.



(a) At 1 second, is the cyclist moving?

If so, in what direction?

Explain your reasoning.

Answer: The cyclist is moving West at one second since the velocity is negative at that time.

(b) At 1 second, is the cyclist accelerating?

If so, in what direction?

Explain your reasoning.

Answer: The cyclist is accelerating to the East since the slope of the line, which tells us the acceleration, is positive. The acceleration is constant throughout the interval graphed.

(c) At 9 seconds, is the cyclist moving?

If so, in what direction?

Explain your reasoning.

Answer: At nine seconds the cyclist is moving East since the velocity is positive at that time.

d) At 9 seconds, is the cyclist accelerating?

If so, in what direction?

Explain your reasoning.

Answer: The cyclist is accelerating to the East throughout.

(e) At 4 seconds, is the cyclist moving?

If so, in what direction?

Explain your reasoning.

Answer: At four seconds the cyclist is stopped instantaneously while changing direction.

(f) At 4 seconds, is the cyclist accelerating?

If so, in what direction?

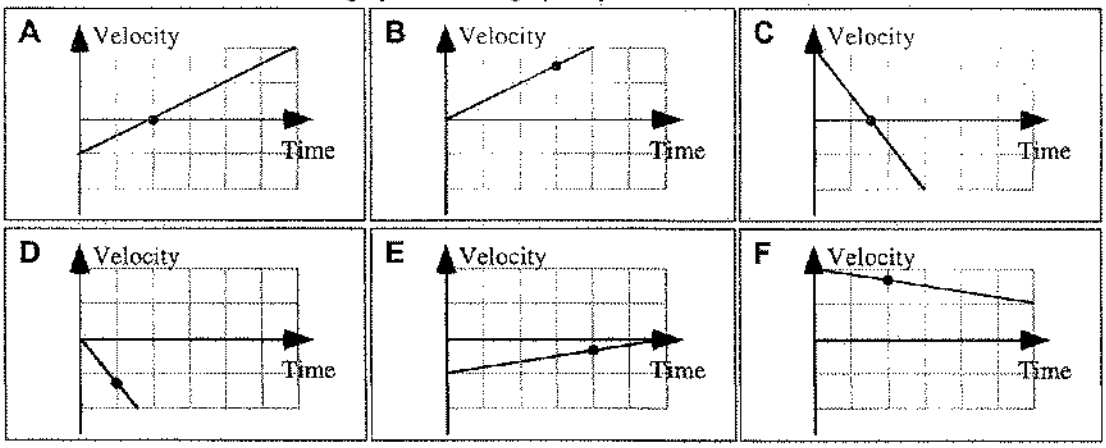
Explain your reasoning.

Answer: As stated above the cyclist is accelerating to the East throughout.

6

B1-RT43: Velocity-Time Graphs—Acceleration

The graphs below show the velocity versus time for boats traveling along a straight, narrow channel. The scales on both axes are the same for all of these graphs. In each graph, a point is marked with a dot.



Rank the magnitude of the acceleration of the boat at the point indicated.

1	2	3	4	5	6	OR	☐	☐	☐
Greatest					Least		All the same	All zero	Cannot determine

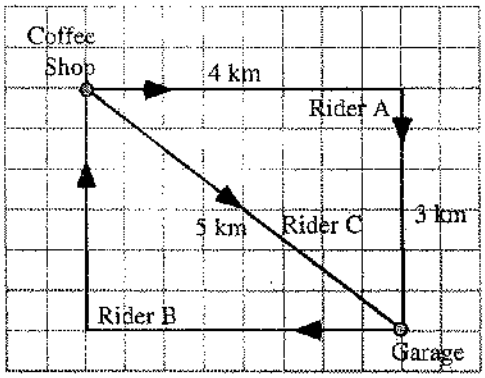
Explain your reasoning.

Answer: $C = D > A = B > E = F$.

The instantaneous accelerations are determined by the slopes of the velocity-time graphs at the given points on the graphs. Since these graphs are straight lines, the slopes (and the accelerations) do not change as a function of time.

B2-SCT02: Motorcycle Trips—Displacement

The paths three motorcyclists took on an afternoon ride are shown. Riders A and C traveled from the coffee shop to the mechanic's garage along different paths, while Rider B traveled from the garage to the coffee shop. Three physics students discussing these rides make the following contentions:



Ali: "The lengths of the paths that Riders A and B travel are the same, so they have the same displacement. Rider C has the smallest displacement."

Bob: "I agree that Rider C has the smallest displacement, because the diagonal path is shortest. But the displacements of Riders A and B are actually different, because their directions are opposite each other."

Carol: "I think the displacements of all three riders are the same, because they go between the same two points. What path they follow doesn't matter."

With which, if any, of these three students do you agree?

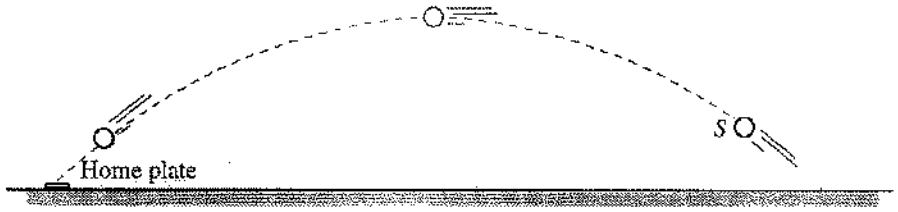
Ali _____ *Bob* _____ *Carol* _____ None of them_____

Explain your reasoning.

Answer: None of them are entirely correct. Bob is correct that the displacements of Riders A and B are opposite to each other, because the diagonal distance is the same with the starting and ending points reversed. But the displacements of Riders A and C are the same because they have the same start and end points.

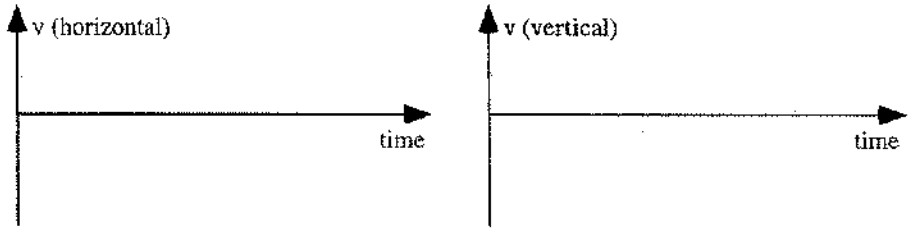
(8) **B2-QRT09: PROJECTILE MOTION—VELOCITY-TIME AND ACCELERATION-TIME GRAPHS**

A baseball is thrown from point *S* in right field to home plate. The dashed line in the diagram shows the path of the ball. Use a coordinate system with up as the positive vertical direction and to the right as the positive horizontal direction, with the origin at the point the ball was thrown from (point *S*).



On the axes below, sketch graphs for the indicated quantities:

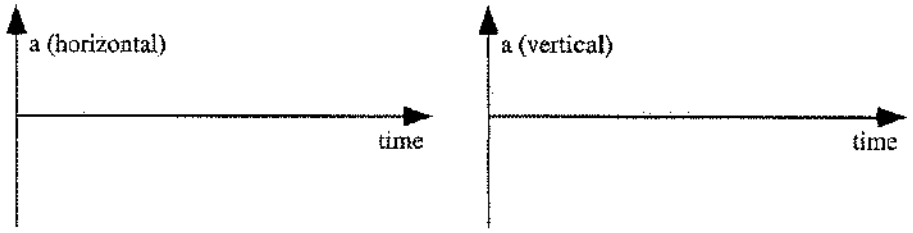
(a) The horizontal velocity versus time and the vertical velocity versus time.



Explain your reasoning.

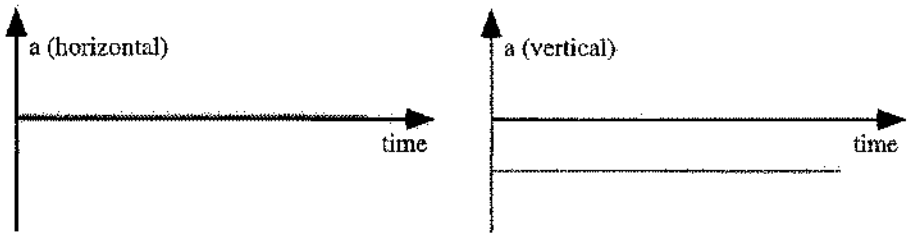
Answer: Since the positive horizontal direction is to the right, the horizontal velocity will be negative. Since up is the positive vertical direction the ball has a positive initial vertical velocity, which decreases to zero and then becomes negative.

(b) The horizontal acceleration versus time and the vertical acceleration versus time.



Explain your reasoning.

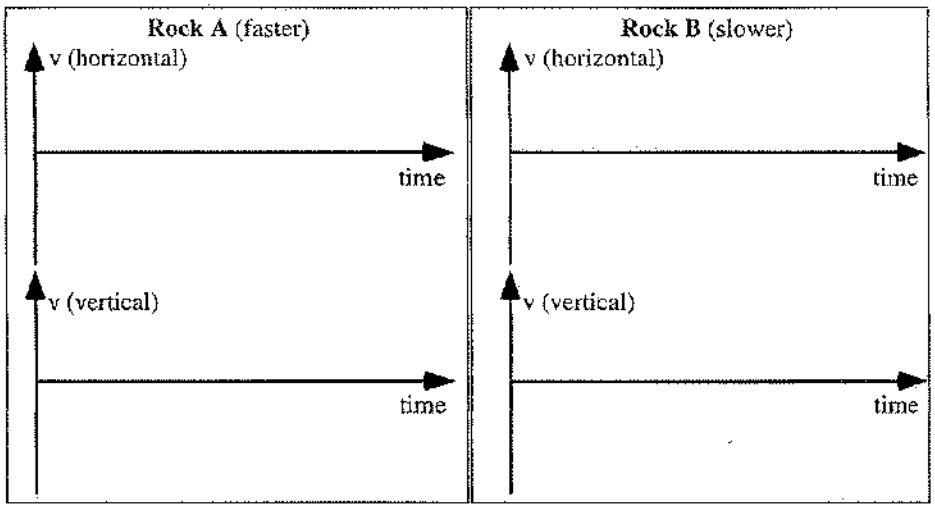
Answer: Since there is no force in the horizontal direction there will be no horizontal acceleration. The vertical acceleration is negative and equal in magnitude to g.

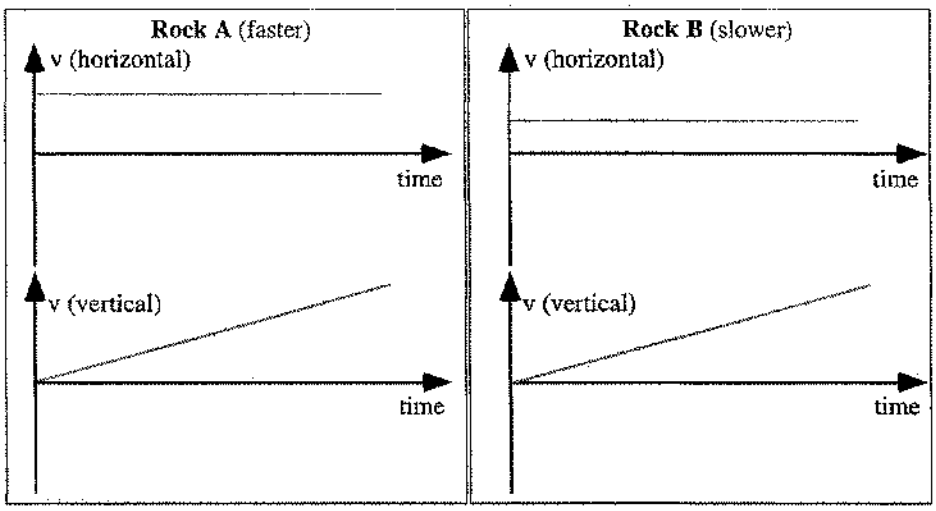


(9) B2-QRT10: PROJECTILE MOTION FOR TWO ROCKS—VELOCITY-TIME AND ACCELERATION-TIME GRAPHS

Two identical rocks are thrown horizontally from a cliff, with Rock A having a greater velocity at the instant it is released than Rock B. Use a coordinate system with down as the positive vertical direction, away from the cliff as the positive horizontal direction, and with the origin of the coordinate system at the bottom of the cliff directly below the release point.

(a) Sketch the **velocity versus time graphs for each of the rocks.**





(b) Which rock hits the ground first?

Explain your reasoning.

Both hit at the same time. Both rocks have the same vertical acceleration and travel the same vertical distance.

(c) Which rock lands farthest from the base of the cliff?

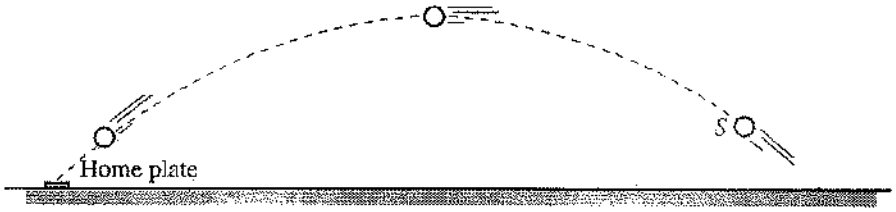
Explain your reasoning

Rock A, the faster rock.

There are no forces in the horizontal direction (ignoring air resistance) so both rocks will have a constant horizontal velocity. Since Rock B is slower than Rock A, it will have a smaller horizontal velocity. Both rocks are thrown horizontally, so they have no initial vertical velocity. Both are acted on by gravity, so the slopes of their vertical velocity graphs are constant and equal to g, and both are positive because gravity is acting down and the positive direction is defined as down. Both rocks hit at the same time but rock A hits further from the cliff since it travels faster in the horizontal direction.

B2-QRT11: Baseball Projectile Motion—Velocity-Time and Acceleration-Time Graphs

A baseball is thrown from point *S* in right field to home plate. The dashed line shows the path of the ball.



Use a coordinate system with up as the positive vertical direction and to the left as the positive horizontal direction, and with the origin at home plate.

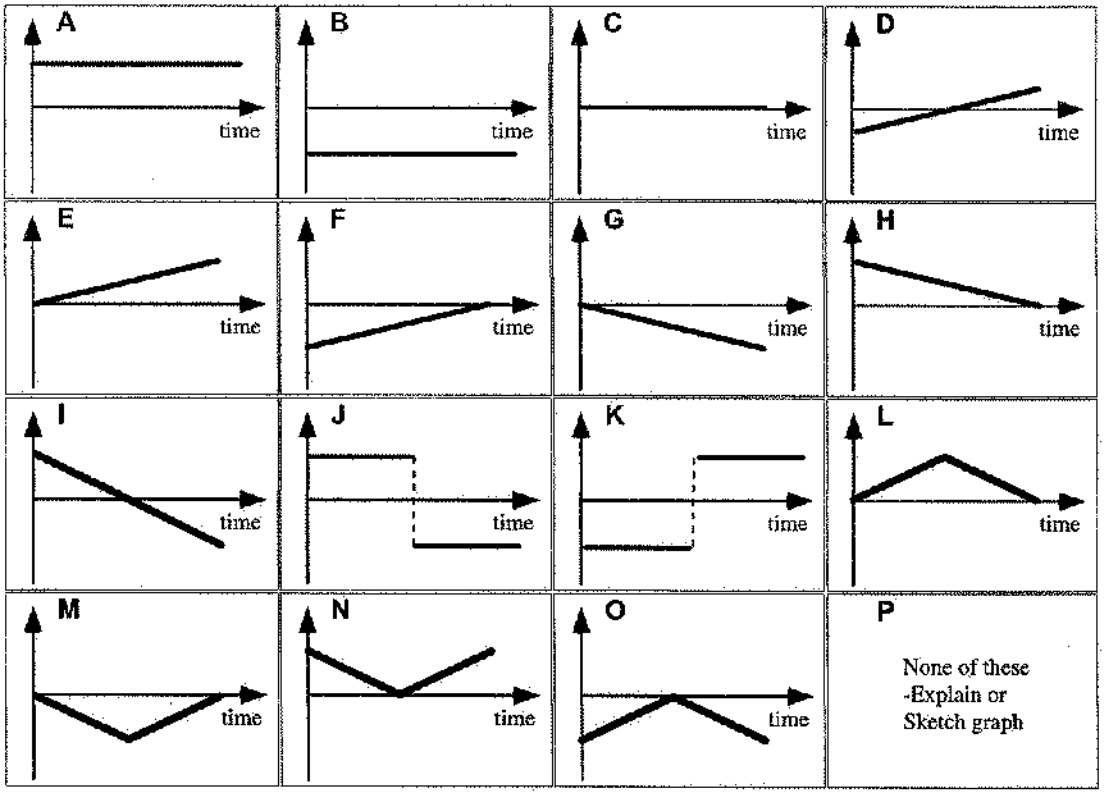
Select the graph from the choices below that best represents:

(i) horizontal velocity versus time graph ____ Explain your reasoning.

(ii) horizontal acceleration versus time graph____ Explain your reasoning.

(iii) vertical velocity versus time graph____ Explain your reasoning.

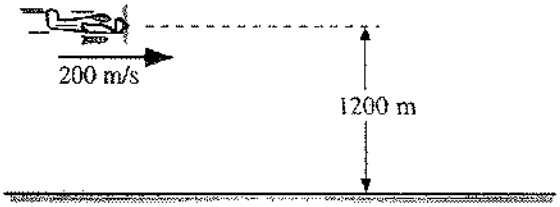
(iv) vertical acceleration versus time graph____ Explain your reasoning.



Answer: (1) A; (2) C; (3) I; and (4) B.
There are no horizontal forces (neglecting air resistance) and the ball will have no horizontal acceleration, so the horizontal velocity will be constant. The positive direction is to the left, so the horizontal velocity will be positive. Since up is positive, the initial vertical velocity is positive, and the final vertical velocity is negative. The only vertical force is gravity acting downward, and so the acceleration is constant, negative, and equal in magnitude to g. Since the acceleration is constant, the slope of the velocity must be constant, so the vertical velocity must be a straight line sloping downward from its initial positive value to its final negative value.

B2-LMCT14: Dropped Practice Bomb—Horizontal Distance Traveled

An airplane is flying 1200 m above the ground at a speed of 200 m/s. It drops a practice bomb that hits the ground after traveling a horizontal distance of 3130 m.



For each of the changes below, use the choices below (i)-(v) to identify what will happen to the horizontal distance the bomb travels while falling compared to the situation above.

(i) The horizontal distance will be ***greater than*** 3130 m.
(ii) The horizontal distance will be ***less than*** 3130 m but not zero.
(iii) The horizontal distance will be ***equal to*** 3130 m.
(iv) The horizontal distance will be ***zero*** (the bomb will drop straight down).
(v) We ***cannot determine*** how this change will affect the horizontal distance.

For each of the following changes, only the feature(s) identified is(are) modified from the given situation above.

(a) The plane's speed is tripled. _____
Explain your reasoning.
A: The time it takes to hit the ground is the same, but the bomb has a greater horizontal velocity.

(b) The plane is climbing straight up at the release point. _____
Explain your reasoning.
D: Since there is no horizontal velocity it will come straight back down if it misses the plane.

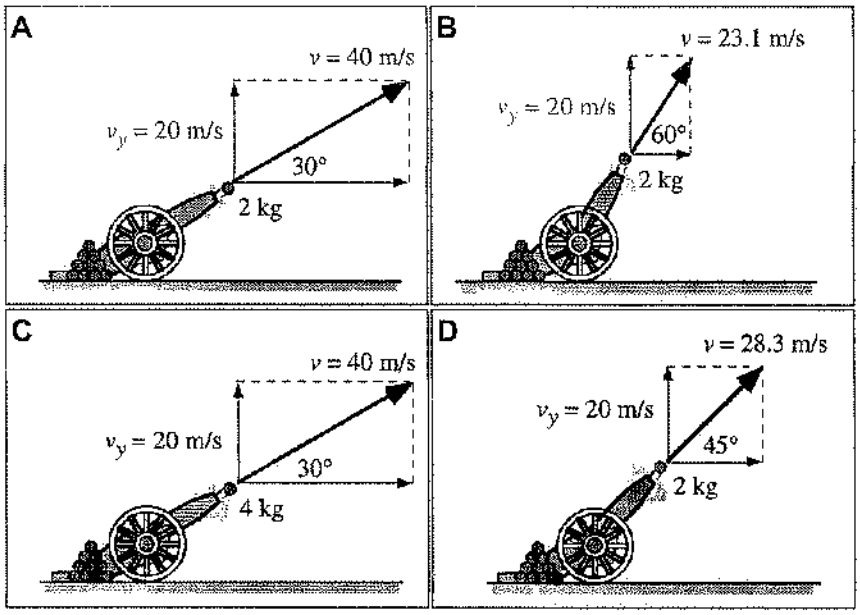
(c) The plane is flying in level flight at an altitude of 1,100 m. _____
Explain your reasoning.
B: It will take less time to reach the ground from a lower height, and the horizontal speed is the same.

(d) The mass of the bomb is increased. _____
Explain your reasoning.
C: The vertical acceleration is still g and is independent of the mass, so the path the bomb takes will remain the same.

(e) The bomb is thrown from the plane with a vertical downward velocity of 15 m/s. _____
Explain your reasoning.
B: The acceleration of the bomb is the same, but with an initial downward vertical velocity it will reach the fground faster, and so will travel less horizontal distance.

(12) **B2-RT21: CANNONBALLS—TIME IN AIR**

Cannonballs with different masses are shot from cannons at various angles above the horizontal. The velocity of each cannonball as it leaves the cannon is given, along with the same vertical component of that velocity.



Rank the time the cannonballs are in the air.

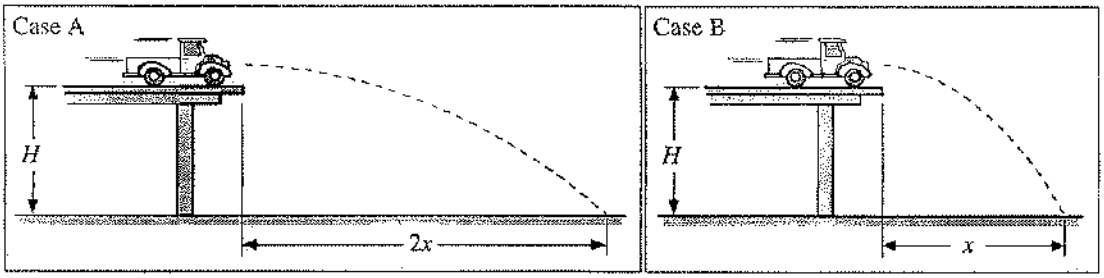
				OR			
					☐	☐	☐
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Answer: All the same. The time in the air is determined by the vertical component of the velocity because it will be the sum of the time the ball takes to get to the top of its trajectory plus the time back down to the ground. Since these cannon balls are all fired from ground and return to ground the time in the air will be twice the time up to the top of the trajectory. Since all of these cases have the same vertical component of the velocity and the same vertical acceleration of 9.8 m/s^2 they will all take the same time.

(13) B2-WWT22: HORIZONTALLY LAUNCHED TOY TRUCKS—TIME IN AIR II

A toy truck is launched horizontally from a table. In Case A the toy truck hits the floor a horizontal distance $2x$ from the edge of the table, and in Case B the toy truck hits the floor a horizontal distance x from the table.



A student comparing the time the trucks are in the air in these cases states:

"The farther you go, the longer it takes to get there. The truck in Case A will be in the air longer."

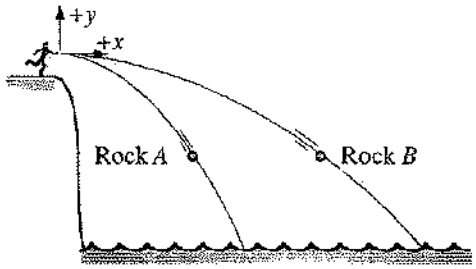
What, if anything, is wrong with this statement? If something is wrong, identify it and explain how to correct it. If this statement is correct, explain why.

Answer: The student's statement is incorrect.

If two objects are traveling with the same speed, then it is true that the object that travels the longest distance will take the most time. In this case, however, the toy truck in case A is in the air just as long as the truck in case B, since they both travel the same vertical distance with the same acceleration, but the truck in case A has the larger horizontal speed.

(14) **B2-CT25: PROJECTILE MOTION FOR TWO ROCKS—VELOCITY AND ACCELERATION**

Two identical rocks are thrown horizontally from a cliff with different velocities. The rocks are thrown at the same time and are shown below while they are still in the air after a few seconds.



For the instant shown:

(a) Will the magnitude of the horizontal velocity of Rock A be (i) *greater than,* (ii) *less than,* or (iii) *equal to* the magnitude of the horizontal velocity of Rock B? _____

Explain your reasoning.

Answer: less, since the picture shows Rock A lands closer to the cliff than Rock B and thus the horizontal velocity of Rock A is smaller than Rock B

(b) Will the magnitude of the vertical velocity of Rock A be (i) *greater than,* (ii) *less than,* or (iii) *equal to* the magnitude of the vertical velocity of Rock B? _____

Explain your reasoning.

Answer: equal, due to both being released with zero vertical velocity and having the same downward acceleration.

(c) Will the magnitude of the horizontal acceleration of Rock A be (i) *greater than,* (ii) *less than,* or (iii) *equal to* the magnitude of the horizontal acceleration of Rock B? _____

Explain your reasoning.

Answer: equal, both have zero horizontal acceleration since we are ignoring air friction.

(d) Will the magnitude of the vertical acceleration of Rock A be (i) *greater than,* (ii) *less than,* or (iii) *equal to* the magnitude of the vertical acceleration of Rock B? _____

Explain your reasoning.

Answer: equal, due to the fact that both have the same acceleration of gravity.