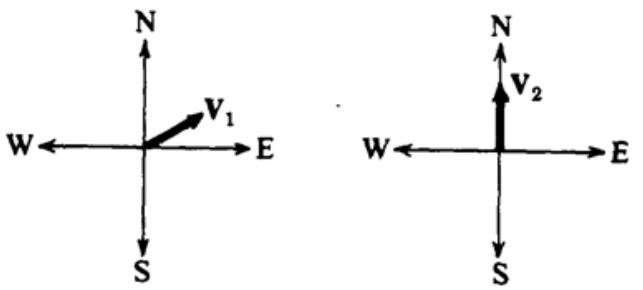
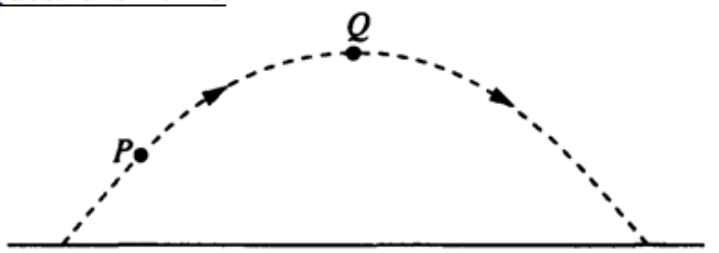
6. Two people are in a boat that is capable of a maximum speed of 5 kilometers per hour in still water, and wish to cross a river 1 kilometer wide to a point directly across from their starting point. If the speed of the water in the river is 5 kilometers per hour, how much time is required for the crossing?
(A) 0.05 hr (B) 0.1 hr (C) 1 hr (D) 10 hr
(E) The point directly across from the starting point cannot be reached under these conditions.



7. Vectors V_1, and V_2 shown above have equal magnitudes. The vectors represent the velocities of an object at times t_1, and t_2, respectively. The average acceleration of the object between time t_1 and t_2 was
(A) zero (B) directed north (C) directed west (D) directed north of east (E) directed north of west

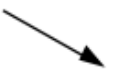
10. A projectile is fired from the surface of the Earth with a speed of 200 meters per second at an angle of 30° above the horizontal. If the ground is level, what is the maximum height reached by the projectile?
(A) 5 m (B) 10 m (C) 500 m (D) 1,000 m (E) 2,000 m

Questions 27-28



A ball is thrown and follows a parabolic path, as shown above. Air friction is negligible. Point Q is the highest point on the path.

27. Which of the following best indicates the direction of the acceleration, if any, of the ball at point Q ?

(A) (B)  (C)  (D)

(E) There is no acceleration of the ball at point Q.

28. Which of the following best indicates the direction of the net force on the ball at point P ?

(A)  (B) (C)  (D)  (E)

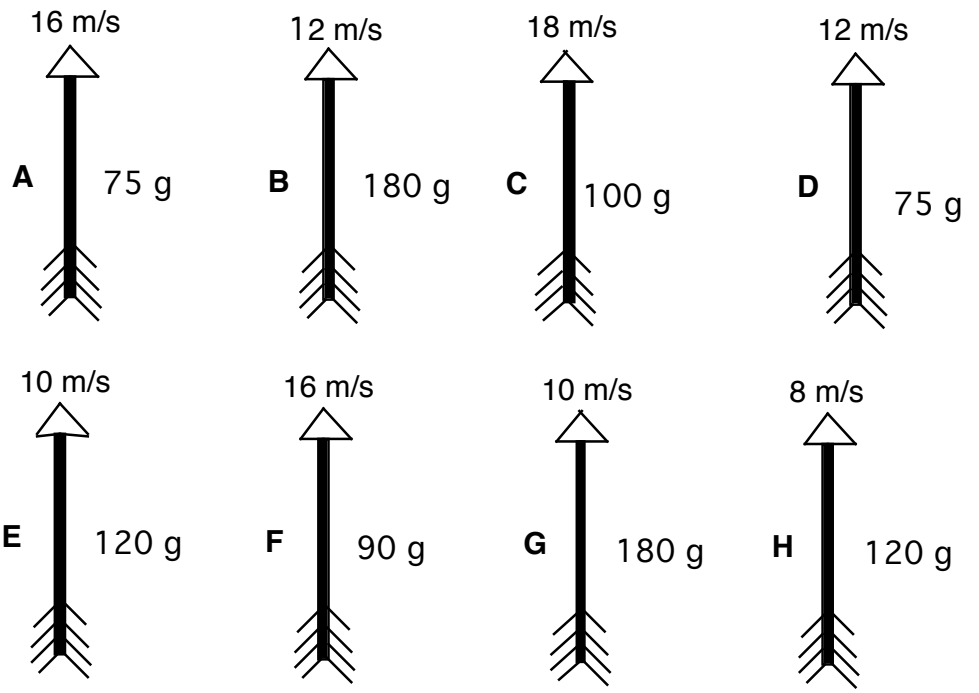
33. A rock is dropped from the top of a 45-meter tower, and at the same time a ball is thrown from the top of the tower in a horizontal direction. Air resistance is negligible. The ball and the rock hit the level ground a distance of 30 meters apart. The horizontal velocity of the ball thrown was most nearly

(A) 5 m/s (B) 10 m/s (C) 14.1 m/s (D) 20 m/s (E) 28.3 m/s

Arrows—Acceleration[19]

The eight figures below show arrows that have been shot into the air. All of the arrows were shot straight up and are the same size and shape. The arrows are made of different materials so they have different masses, and they have different speeds as they leave the bows. The values for each arrow are given in the figures. (We assume for this situation that the effect of air resistance can be neglected.) All start from same height.

Rank these arrows, from greatest to least, on the basis of the acceleration of the arrows at the top of their flight.



Greatest 1_____ 2_____ 3_____ 4_____ 5_____ 6_____ 7_____ 8_____ Least

All arrows have the same acceleration but not zero. _____

The acceleration at the top is zero for all these. _____

Please carefully explain your reasoning.

How sure were you of your ranking?

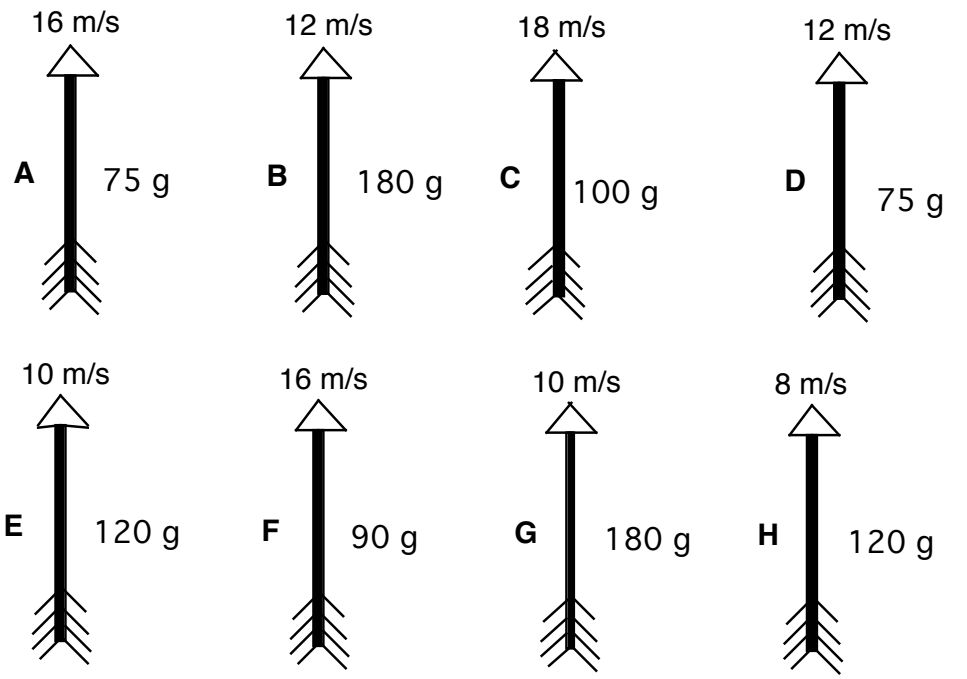
Basically Guessed					Sure				Very Sure
1	2	3	4	5	6	7	8	9	10

[19] T. O'Kuma, D. Maloney

Vertical Arrows—Maximum Height [7]

The eight figures below show arrows that have been shot into the air. All of the arrows were shot straight up and are the same size and shape. But the arrows are made of different materials so they have different masses, and they have different speeds as they leave the bows. The values for each arrow are given in the figures. (We assume for this situation that the effect of air resistance can be neglected.) All start from same height.

Rank these arrows, from greatest to least, on the basis of the maximum heights the arrows reach.



Highest 1_____ 2_____ 3_____ 4_____ 5_____ 6_____ 7_____ 8_____ Lowest

Or, all the arrows reach the same height. _____

Please carefully explain your reasoning.

How sure were you of your ranking? (circle one)

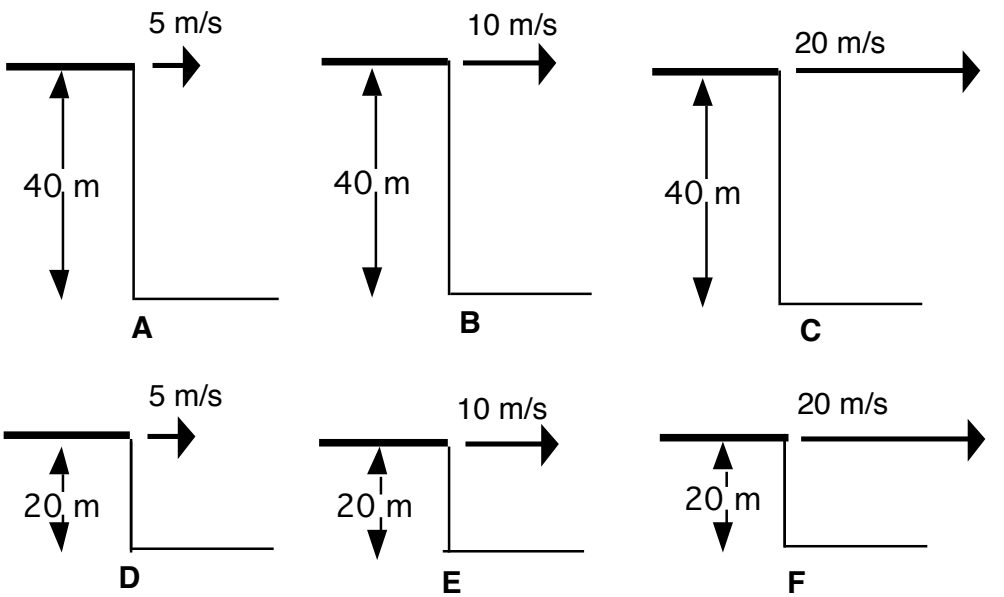
Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

[7] T. O'Kuma

Water Over a Waterfall—Time to Reach Ground [44]

Pictured below are six waterfalls all of which have the same amount of water flowing over them. The waterfalls differ in height and in the speed of the water as it goes over the edge. The specific values of the heights and speeds are given in the figures.

Rank these situations from longest to shortest based on how long it takes the water to go from the top of the falls to the bottom. That is, put first the situation where it takes the water the most time to go from the top of the falls to the bottom, and put last the one that takes the least time.



Longest 1 _____ 2 _____ 3 _____ 4 _____ 5 _____ 6 _____ Shortest

Or, water from all of the waterfalls reaches the bottom at the same time. _____
Please carefully explain your reasoning.

How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

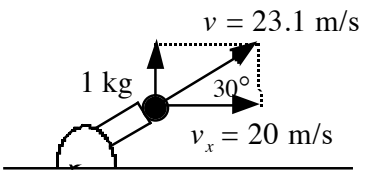
[44] D. Maloney

Projectile—Horizontal Distance [54]

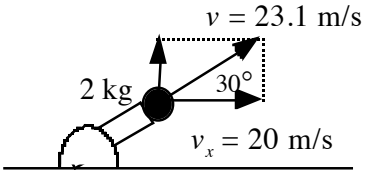
The pictures below depict cannonballs of two different masses projected upward and forward. The cannonballs are projected at various angles above the horizontal, but all are projected with the same horizontal component of velocity.

Rank according to the horizontal distance traveled by the balls.

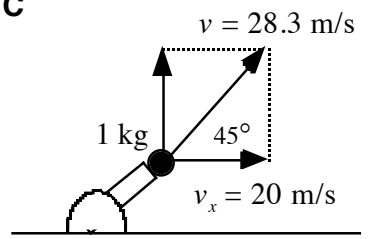
A



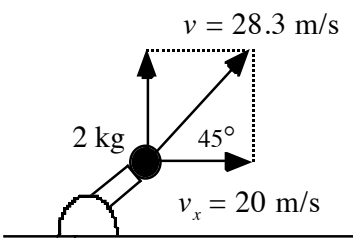
B



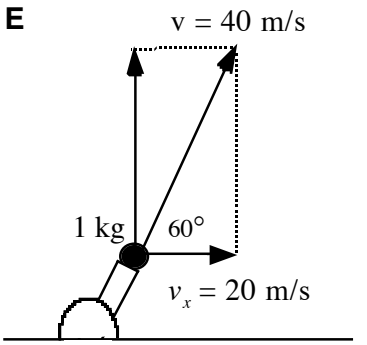
C



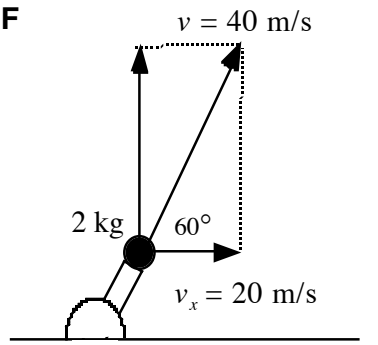
D



E



F



Largest 1_____ 2_____ 3_____ 4_____ 5_____ 6_____ Smallest

All distances traveled are the same. _____

Please carefully explain your reasoning.

How sure were you of your ranking? (circle one)

Basically Guessed				Sure					Very Sure
1	2	3	4	5	6	7	8	9	10

[54] S. Heath

Hints Page

6. The only way to cancel out the current is for the y-component of your rowing velocity to cancel out the current.

7. The change in velocity vector goes from the end of the v1 vector to the end of the v2 vector.

10. What is the y-component of the velocity? (Note: sin(30)=0.5)

27. Does gravity turn off at the top?

28. If the object has no drag, there's only one force acting on it once it's in flight.

33. They picked 45 m for a reason - it's one of the free fall distances.

Ranking Task: Arrows Acceleration: Does gravity turn off at the top?

Ranking Task: Arrows Maximum Height: Does mass matter (once they're up to speed and released)?

Ranking Task: Time to Reach the Ground: Does horizontal velocity affect vertical fall?

Ranking Task: Horizontal Distance: They all have the same Vxo. Which ones get more time to travel?

Answers Page

6. E

7. E

10. C

27. C

28. D

33. B

Ranking Task: Arrows Acceleration:
greatest - [A, B, C, D, E, F, G, H] - least

Ranking Task: Arrows Maximum Height:
greatest - C, [A, F], [B, D], [E, G], H - least

Ranking Task: Time to Reach the Ground:
greatest - [A, B, C], [D, E, F] - least

Ranking Task: Horizontal Distance:
greatest - [E, F], [C, D], [A, B] - least