a place of mind

FACULTY OF EDUCATION

Department of
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Physics
2D Kinematics

Science and Mathematics
Education Research Group

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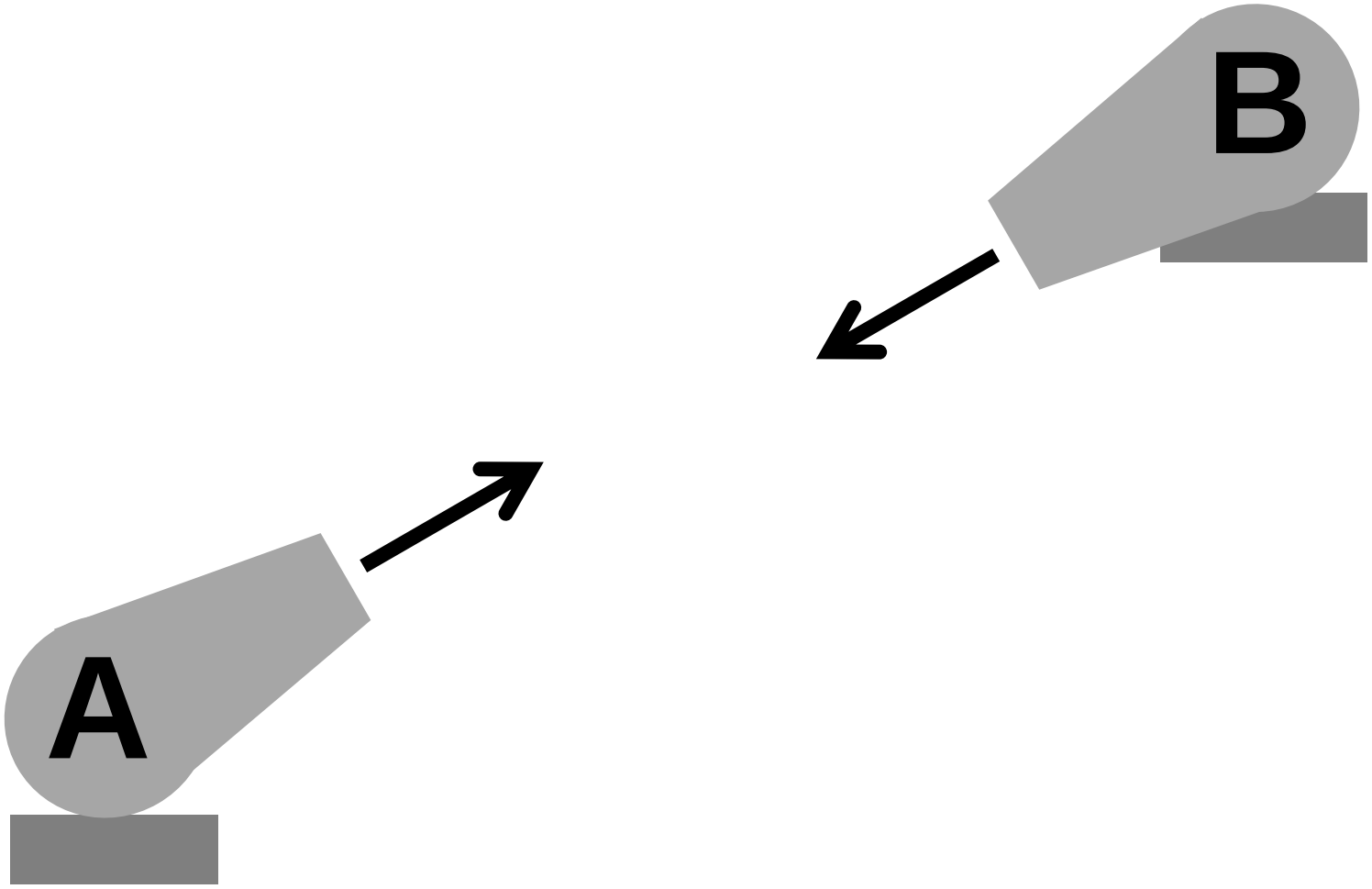
Two Cannon Problem



Cannonball Trajectories

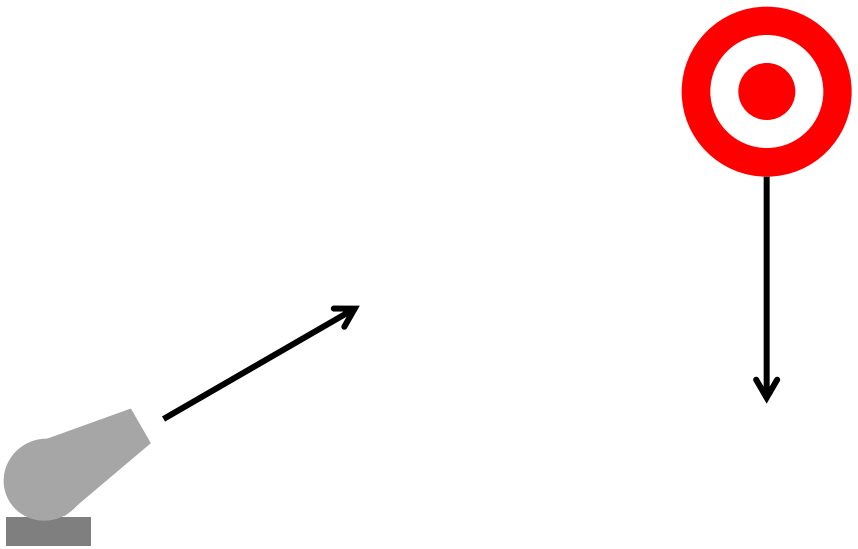
A cannon is pointed at a target. The cannon shoots a cannonball with a non-zero velocity at the target. At the same time, the target begins to fall with zero initial velocity. Will the cannonball hit the target?

A. It depends on the initial velocity of the cannonball

B. It depends on the distance between the cannon and the target

C. Yes, it will hit the target

D. Both A and B



Solution

Answer: C

Justification: In a situation without gravity, the cannonball will continue in a straight line and hit the stationary (not-moving) target. When gravity is taken into account, both the cannonball and the target have the same vertical acceleration (g), and as soon as released, they will start falling down at the same rate. Since gravity has an equal effect on both the cannonball and the target (both will have the same acceleration), the cannonball will hit the target as long as they released simultaneously.

Two Cannon Problem I

Two cannons are perched on top of cliffs separated by a large gap. The cannons are pointed toward each other and each cannon shoots a cannonball with a non-zero velocity at the same time. Assuming there is no gravity or air resistance, will the cannonballs collide?

A. Yes, they will collide

B. It depends on the velocity of the cannonballs

C. It depends on the distance between the cannons

D. Both B and C

Solution

Answer: A

Justification: There is no gravity to pull the cannonballs down, so the cannonballs will travel in a straight line and will hit each other regardless of the initial velocity.

Two Cannon Problem II

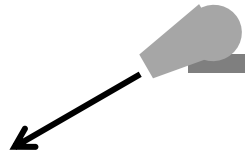
Two cannons are perched on top of cliffs separated by a large gap. The cannons are pointed toward each other and each cannon shoots a cannonball with a non-zero velocity at the same time. Assuming there is no gravity or air resistance, will the cannonballs collide?

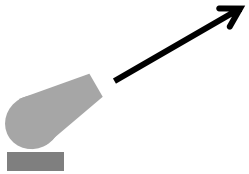
A. Yes, they will collide

B. It depends on the velocity of the cannonballs

C. It depends on the distance between the cannons

D. Both B and C





Solution

Answer: A

Justification: In a situation without gravity, the cannonballs will travel in straight lines. The two cannons are pointed directly at each other, so the trajectories line up.

The cannonballs will collide regardless of their initial velocities.

Two Cannon Problem III

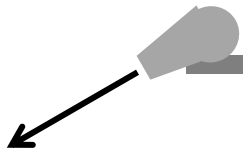
Two cannons are perched on top of cliffs separated by a deep gap. The cannons are pointed toward each other and each cannon shoots a cannonball with a non-zero velocity at the same time. Ignoring air resistance, will the cannonballs collide?

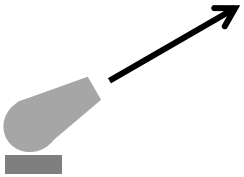
A. Yes, they will collide

B. It depends on the velocity of the cannonballs

C. It depends on the distance between the cannons

D. Both B and C





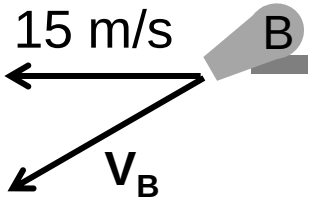
Solution

Answer: A

Justification: Considering a situation where there is no gravity, such as the that in the previous question, the cannonballs will travel in a straight line and will hit each other regardless of the initial velocity. With the inclusion of gravitational acceleration, both of the cannonballs fall at the same rate. Since they both have the same vertical acceleration, they will move toward each other in a straight line in the reference frame of the cannonballs. The initial velocity and the distance between the cannons do not matter as gravity affects the parameters equally.

Two Cannon Problem IV

Two cannons are perched on top of cliffs separated by a 150 m gap. The cannonballs are shot towards each other at different velocities. Cannon A shoots a cannonball with a horizontal velocity component of 10 m/s to the right. Cannon B shoots a cannonball with a horizontal velocity component of 15 m/s to the left. How long does it take for the cannonballs to collide?



A. They will not collide

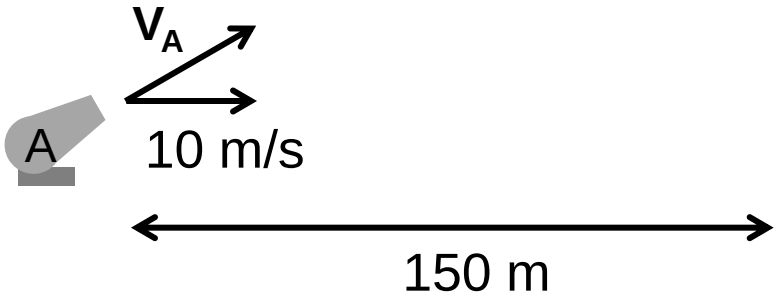
B. 15 s

C. 10 s

D. 6 s

E. 4 s

F. Not enough information



Solution

Answer: D

Justification: We know that the cannonballs will hit regardless of their initial speeds, as long and their velocities are directed towards each other. So in this situation we only need to consider horizontal velocity for the horizontal distance between the cannons.

When the cannonballs collide, the total distance they have travelled will be 150 m.

We need to solve the equation, t(10 m/s) + t(15 m/s) =150 m, adding the distance travelled by each of the cannons, to find the time they meet.

(25 m/s)t = 150 m $\rightarrow$ t = 6 s

Two Cannon Problem V

Two cannons are perched on top of cliffs separated by a 150 m gap. Cannon A is 90 m lower than cannon B and cannon B is pointed directly at cannon A. Cannon A shoots a cannonball with a horizontal velocity of 10 m/s. What must be the vertical velocity of cannonball A for the cannonballs to collide?

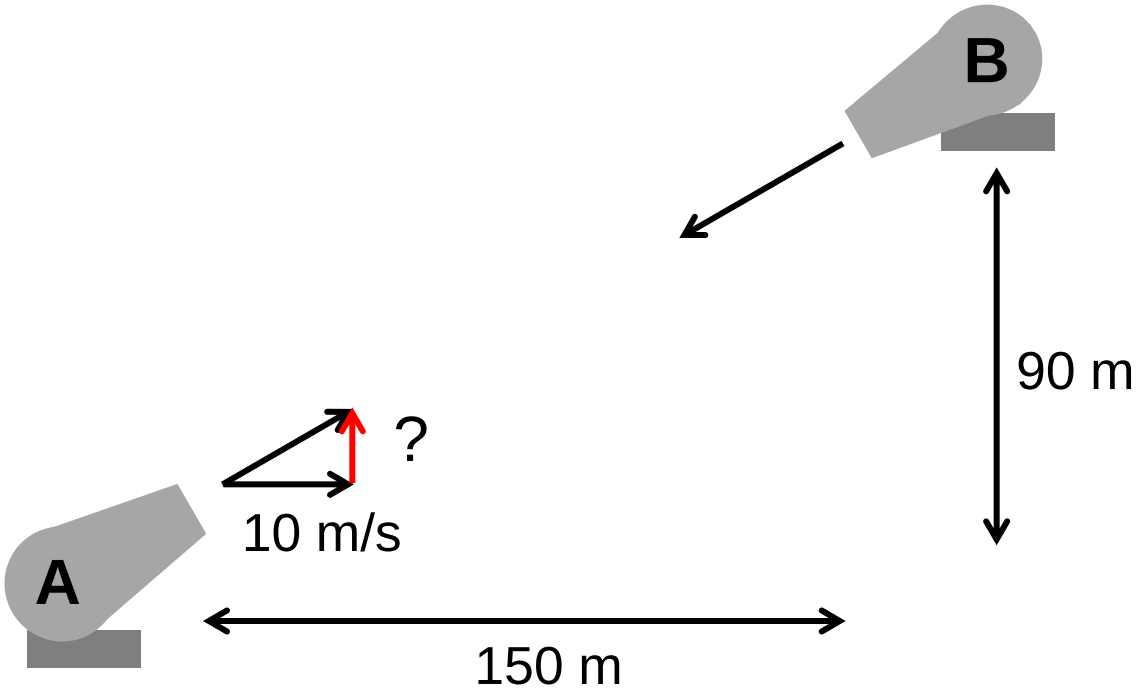
A. 1.7 m/s

B. 5 m/s

C. 5.8 m/s

D. 6 m/s

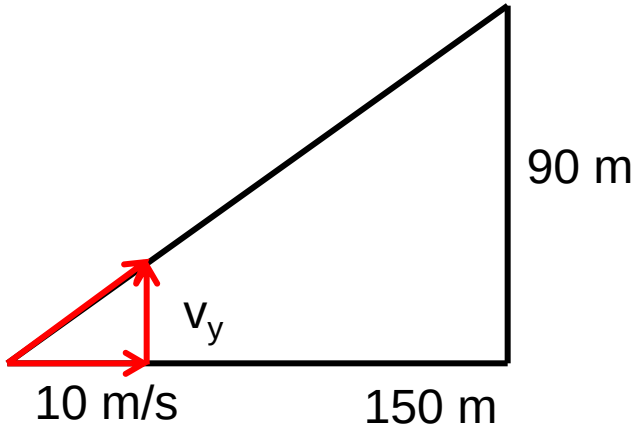
E. None of the above



Solution

Answer: B

Justification: From the previous questions we know that the cannonballs will collide if the cannons are pointing at each other. For cannon A to point at cannon B, the right triangle created by the vector components of its velocity must be congruent to the right triangle formed by the distance between the cannons. We can then find the vertical velocity of cannonball A using the ratio of the vertical distance to the horizontal distance.



$$\frac{v_y}{10\ m/s} = \frac{90\ m}{150\ m} = \frac{3}{5}$$

$$5x = 3 \times 10\ m/s$$

$$v_y = 6\ m/s$$