UBC a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

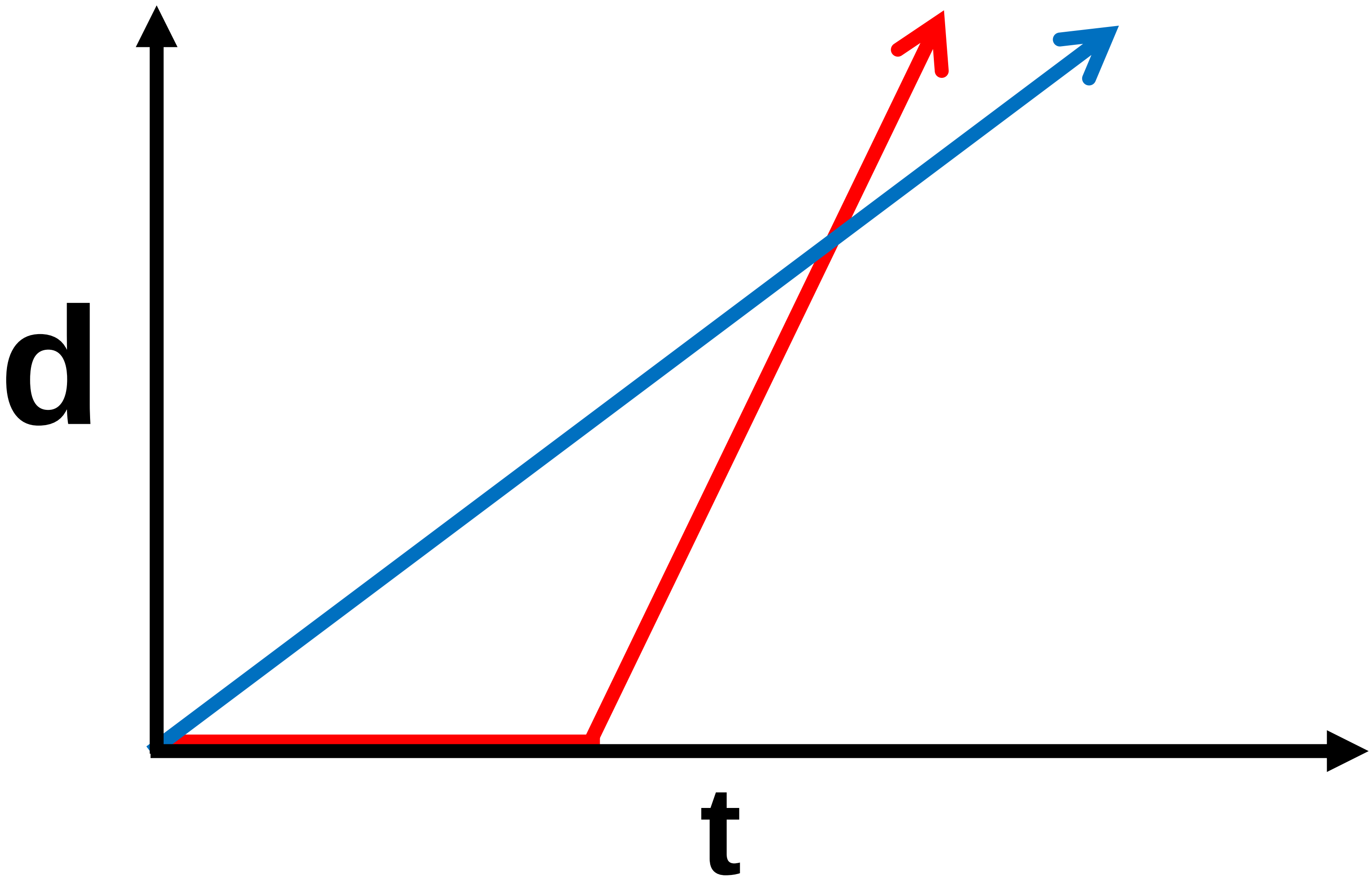
Physics

1-D Kinematics: Velocity and Displacement

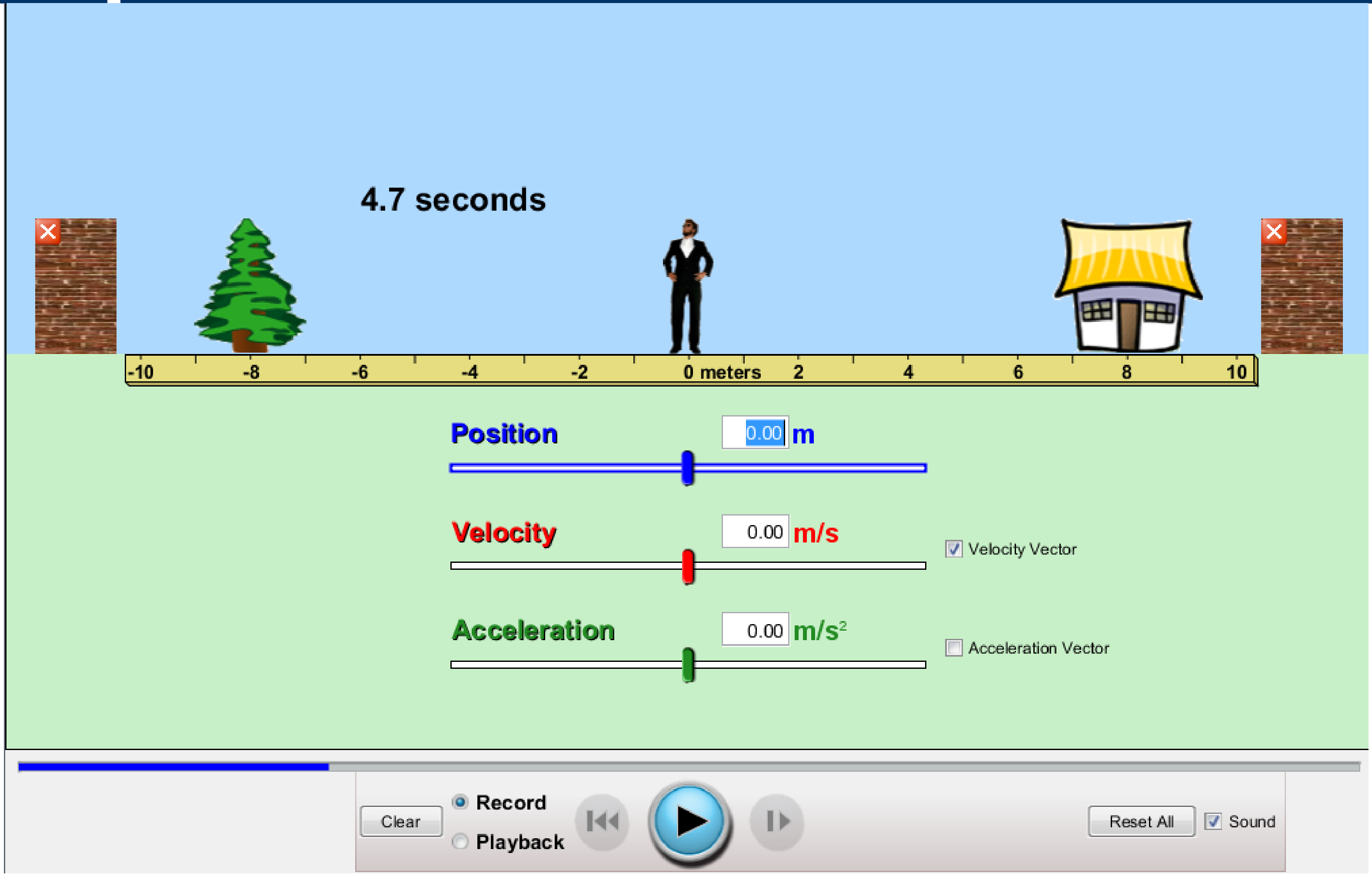
Science and Mathematics
Education Research Group

Supported by UBC Teaching and Learning Enhancement Fund 2012-2013

Modelling a Race



Modelling a Race

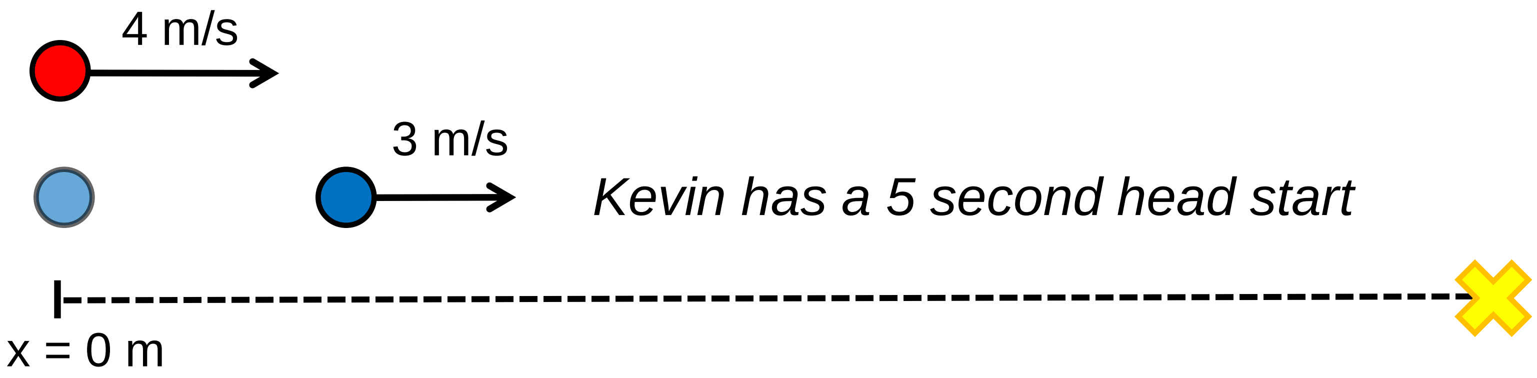


http://phet.colorado.edu/en/simulation/moving-man

The Scenario

Jeremy and Kevin race to school. Jeremy can run at 4 m/s while Kevin at 3 m/s. Since Kevin runs slower than Jeremy, Kevin was given a 5 second head start.

Both Jeremy and Kevin start at x = 0 m. Kevin begins running at t = 0 s, Jeremy begins at t = 5 s.



Racing I

Which equations correctly describe the position of Kevin and Jeremy at any given time t? (Remember both Jeremy and Kevin start at x = 0 m. Kevin begins running at t = 0 s)

	Kevin	**Jeremy**
A.	$x_K = 3t$	$x_J = 0$ m for $t < 5$ s $x_J = 4t$ for $t \geq 5$ s
B.	$x_K = 3t$	$x_J = 0$ m for $t < 5$ s $x_J = 4(t-5)$ for $t \geq 5$ s
C.	$x_K = 3(t+5)$	$x_J = 0$ m for $t < 5$ s $x_J = 4t$ for $t \geq 5$ s
D.	$x_K = 3(t+5)$	$x_J = 0$ m for $t < 5$ s $x_J = 4(t-5)$ for $t \geq 5$ s

Solution

Answer: B

Justification: Notice that all the formulas are in the form $\boldsymbol{x} = \boldsymbol{x}_0 + \boldsymbol{v}t$, where **v** is the velocity of Kevin or Jeremy. In order to account for Jeremy's 5 seconds of waiting, t must be replaced with (t-5)s in his equations.

Answers with $x_K = 3(t+5)$ are incorrect because Kevin starts at t=0 s. If Jeremy started at t=0 s, and Kevin at t= -5 s, this would be correct.

Answers with $x_J = 4t$ for $t \geq 5$ s are incorrect because that would give $x_J = 20$ m for t = 5 s, rather than 0 m.

Try inputting various values of t in the equations from answer B and comparing with the expected values.

Racing II

How long after Kevin starts running does it take for Jeremy to catch up?

A. 5 s

B. 15 s

C. 20 s

D. 25 s

E. Jeremy will never catch up

Solution

Answer: D

Justification:

Solution 1: Kevin's position is $x_K = 3t$. Jeremy's position is $x_J = 4(t-5)$ for $t \geq 5$ s. Letting $x_K = x_J$ gives $t = 20$ s, which is the time when Jeremy and Kevin are at the same point.

$4(t-5) = 3t \rightarrow 4t - 20 = 3t \rightarrow 4t - 3t = 20 \rightarrow t = 20$ s

Solution 2: Kevin's 5s head start is equivalent to a 15m head start. Since Jeremy runs 1m/s faster than Kevin, it will take Jeremy 15 s to make up for this distance. Adding the 5s wait time, Jeremy will catch up with Kevin in 20 s.

Racing III

How far away from the starting point must the finish line be located so that Jeremy wins the race?

A. Exactly 60 m away

B. Greater than 60 m away

C. Exactly 80 m away

D. Greater than 80 m away

E. Jeremy will never cross the finish line before Kevin

Solution

Answer: B

Justification: From the previous question we know that Jeremy will catch up 20 seconds after Kevin first starts running. From question 1, we came up with two equations that give us the position of Jeremy and Kevin:

$$x_K = 3t \text{ and } x_J = 4(t-5) \text{ for } t \geq 5 \text{ s}$$

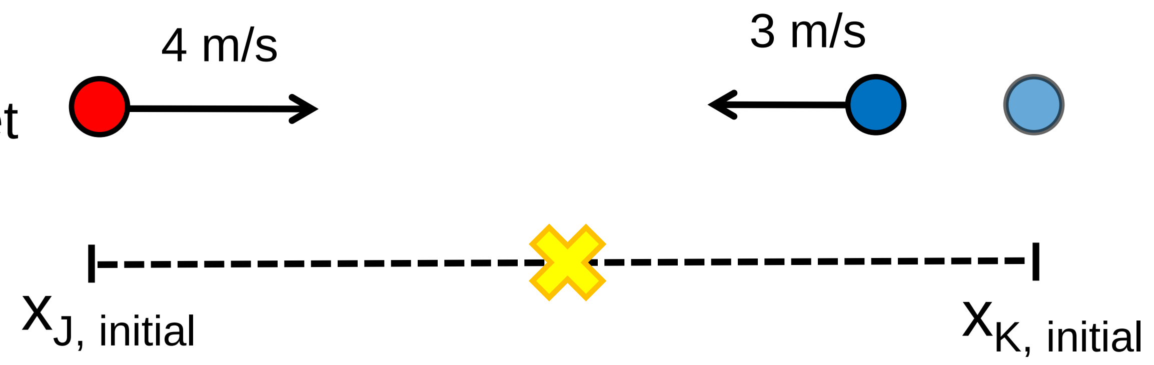
Since we let t = 0 be when Kevin starts running, either of these equations will give us the position of Jeremy and Kevin when they meet at 20 seconds. Letting t = 20 in either equation gives x = 60 m. In order for Jeremy to win the race, the finish line must be any distance <u>farther</u> than 60 m.

Additional activities: Try graphing x_K and x_J on the same position vs. time graph. At what position and time do the 2 lines intersect? When is x_J above x_K?

Racing IV

Jeremy and Kevin start some distance apart from each other. Kevin starts running towards Jeremy at 3 m/s. Five seconds later, Jeremy starts running towards Kevin at 4 m/s. Jeremy and Kevin happen to meet at the midpoint of both their starting locations. How far apart were their starting locations?

A. 30 m
B. 60 m
C. 90 m
D. 120 m
E. It is impossible for them to meet at the midpoint



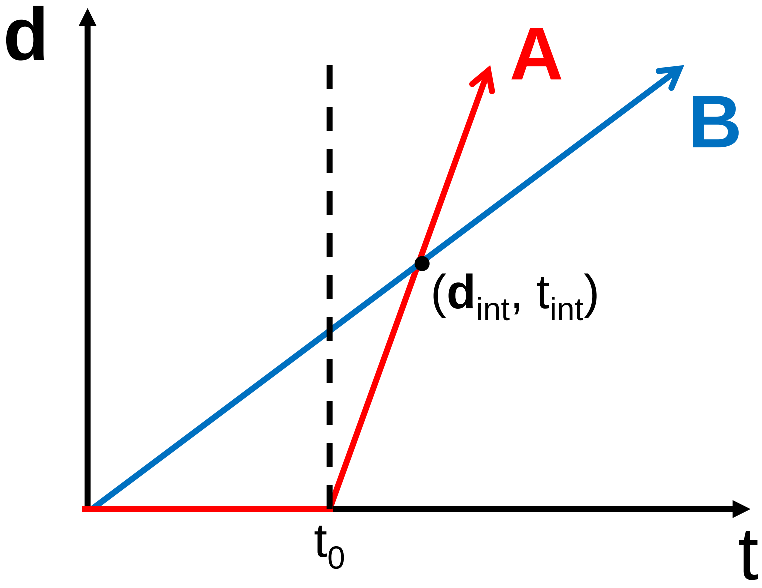
Solution

Answer: D

Justification: We know from the previous question that after 20 seconds, both Jeremy and Kevin have travelled 60 m. This is the *only* time where Jeremy and Kevin have travelled the same distance.

If Jeremy and Kevin want to meet at the midpoint between them, they must both travel the same distance. Therefore, they should start 120 m apart so that they both travel 60 m.

Racing V



The graph shows the ***displacement*** of Runner A and Runner B at different times. The two runners start at the same position. The graphs intersect at point ($\mathbf{d}_{int}$, t_{int}). Who is winning the race? (Assume a displacement to the right is positive, left is negative)

A. Runner A at all times

B. Runner B at all times

C. Runner B before t_{int}, Runner A after t_{int}

D. Runner B before t_0, Runner A after t_0

E. Cannot be determined from a displacement vs. time graph

Solution

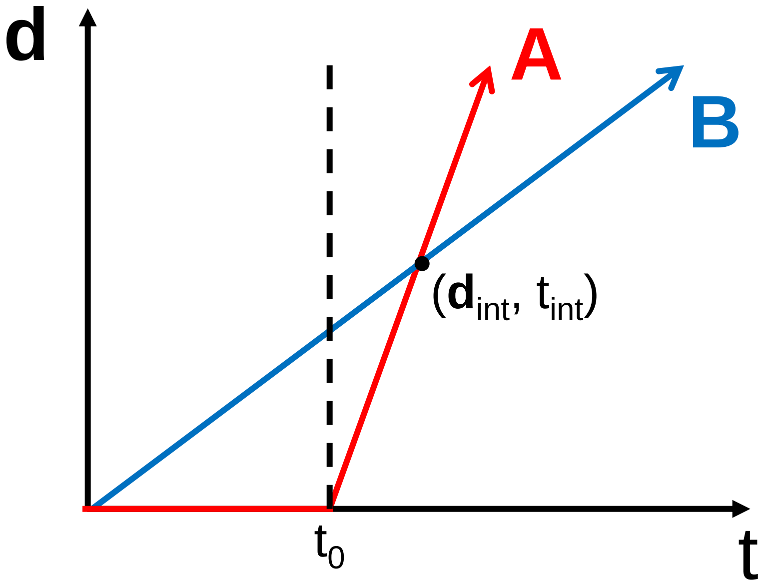
Answer: C

Justification: The runner with the greater displacement is winning the race. Whichever line is above the other has the greater displacement.

The blue line (Runner B) is above the red line before t_{int}.

The red line (Runner A) is above the blue line after t_{int}.

Racing VI



The graph shows the <u>*displacement*</u> of Runner A and Runner B at different times. The graphs intersect at point ($\mathbf{d}_{int}$, t_{int}). Who runs at the greater velocity? (Assume a displacement to the right is positive, left is negative)

A. Runner A at all times

B. Runner B at all times

C. Runner A before t_{int}, Runner B after t_{int}

D. Runner B before t_0, Runner A after t_0

E. Cannot be determined from a displacement vs. time graph

Solution

Answer: D

Justification: Before t_0, Runner B is moving at constant velocity while Runner A is stationary. Therefore, Runner B has the greater velocity before t_0.

After t_0, the slope of the line from Runner A is steeper than Runner B. This means that Runner A is displaced by a greater amount in the same amount of time. Therefore, Runner A has the greater velocity after t_0.