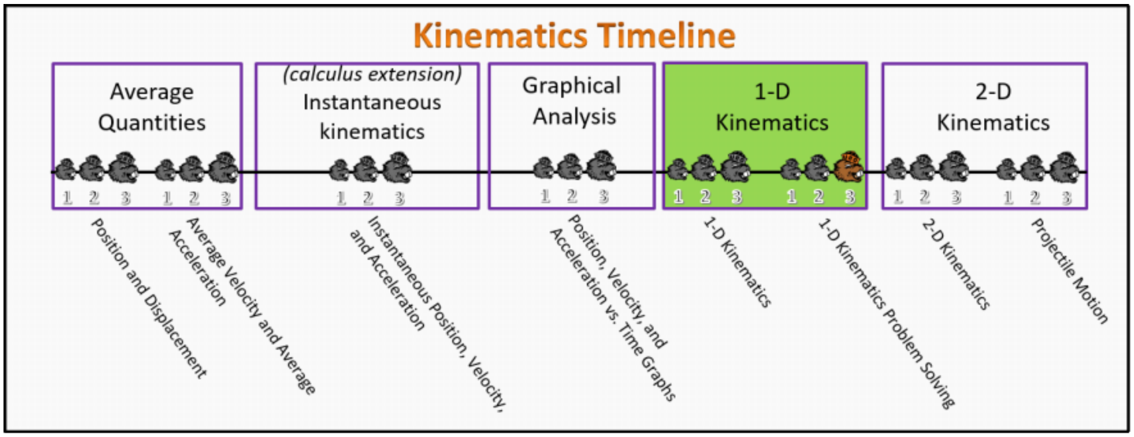
(K1.L2.3-sols) Practice Stage Solutions

Thursday, March 29, 2018 8:34 PM

1-D Kinematics

Foundation Stage (K1.L2.3)

Post-Lecture 2
1-D Kinematics Problem Solving



Questions

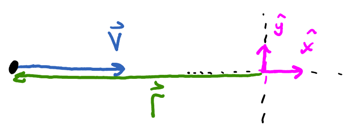
K1.L2.3-01

Description: Direction of velocity and acceleration.

Learning Objectives: [x]

Problem Statement: An object moving along a straight line has its velocity pointing in the opposite direction of its position. Which *one* of the following statements concerning the object is *necessarily* true?

? (1) The value of the acceleration is negative.
? (2) The direction of the acceleration is in the opposite direction as the displacement.
? (3) The direction of the acceleration is in the direction opposite to that of the velocity.
4 (4) The object is moving towards the origin.
? (5) The object is slowing down.



K1.L2.3-02

Description: Proportional reasoning with changing acceleration to change time with constant displacement.

Learning Objectives: [x]

Problem Statement: A Tesla electric car has a mode called Ludicrous Mode where the average acceleration is sixteen ninths times the standard mode. By what factor would the time to travel the same distance change?

(1) Ludicrous mode would take nine sixteenths the time as the standard mode.
(2) Ludicrous mode would take three fourths the time as the standard mode.
(3) Ludicrous mode would take the same amount of time as the standard mode.
(4) Ludicrous mode would take sixteen ninths the time as the standard mode.
(5) Ludicrous mode would take four thirds the time as the standard mode.

$$\Delta X = \cancel{v_{ix}}^{0}\Delta t + \tfrac{1}{2} a_x \Delta t^2$$

$$\Delta X = \tfrac{1}{2} a_x \Delta t^2$$

↑ const

$$\Delta t \propto \frac{1}{\sqrt{a_x}}$$

If $a_x \to \frac{16}{9} a_x$

Then $\Delta t \to \frac{1}{\sqrt{\frac{16}{9}}}\Delta t = \frac{1}{\left(\frac{4}{3}\right)}\Delta t = \frac{3}{4}\Delta t$

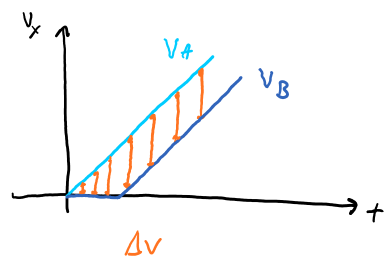
K1.L2.3-03

Description: Two balls dropped from roof, difference in speeds.

Learning Objectives: [x]

Problem Statement: Two balls are dropped from the roof of a tall building and undergo free-fall. They are not dropped at the same time, one is dropped a short moment after the first. As time progresses, the difference in their speeds

(1) decreases.
(2) increases.
(3) remains constant.
(4) decreases initially, but then remains constant.
(5) increases initially, but then remains constant.



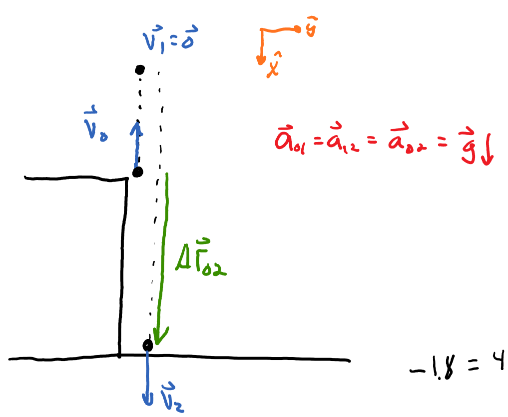
K1.L2.3-04

Description: Diver jumps into the water from a height above.

Learning Objectives: [x]

Problem Statement: A diver bounces straight up from a diving board, avoiding the diving board on the way down, and falls feet first into a pool. She starts with a velocity of 4.00 m/s and her takeoff point is 1.80 m above the pool. Use g = 9.82 m/s²

(a) How long, in seconds, are her feet in the air?



0 → 2

X

K	UK
$\Delta X_{02} = 1.8\,m$	
$v_{0x} = -4\,m/s$	v_{2x}
$a_{02x} = 9.82\,m/s^2$	Δt_{02}

$$\Delta X_{02} = v_{0x}\Delta t_{02} + \tfrac{1}{2} a_{02x}\Delta t_{02}^2$$

$$1.8 = -4\Delta t_{02} + \tfrac{1}{2}(9.82)\Delta t_{02}^2$$

$$4.91\Delta t_{02}^2 - 4\Delta t_{02} - 1.8 = 0$$

$$-1.8 = 4X - 4.91X^2$$

$\Delta t_{02} = 1.13707$ sec ✓ $\boxed{\Delta t_{02} = 1.14 \text{ sec}}$

or

$= -0.32241$ sec ✗

(b) What is her speed, in m/s, when her feet hit the water?

$$V_{fx} = V_{ix} + a_x \Delta t$$

$$V_{2x} = V_{0x} + a_{02x} \Delta t_{02}$$

$$V_{2x} = -4 + 9.82(1.13707\ \text{sec})$$

$$V_{2x} \approx 7.16603\ \text{m/s}$$

$$\boxed{|\vec{V}_2| \approx 7.17\ \text{m/s}}$$

(c) What is her highest point, in meters, above the board?

$0 \to 1$

x

K	UK
$V_{0x} = -4\ \text{m/s}$	ΔX_{01}
$V_{1x} = 0$	
$a_{01x} = 9.82\ \text{m/s}^2$	Δt_{01}

$$V_{1x}^2 = V_{0x}^2 + 2a_{01x}\Delta X_{01}$$

$$0 = -(4\ \text{m/s})^2 + 2(9.82)\Delta X_{01}$$

By ANS

$$\Delta X_{01} \approx 0.81466\ \text{m}$$

$$\boxed{\Delta X_{01} \approx 0.815\ \text{m}}$$

K1.L2.3-05

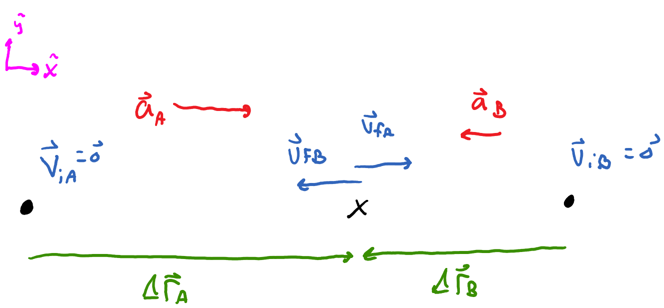
Description: Time and distance with constant acceleration.

Learning Objectives: [x]

Problem Statement: Two rugby players start from rest, they are 46 m away from each other. Each player runs directly toward the other, both of them are accelerating. One player's acceleration has a magnitude of 0.60 m/s^2. The second player's acceleration has a magnitude of 0.40 m/s^2.

(a) How much time passes before the players collide?

(1) 3.40 s
(2) 6.46 s
(3) 9.59 s
(4) 52.1 s
(5) 92.0 s



A

K	UK
$V_{iAx} = 0$	ΔX_A
$a_{Ax} = .6\ \text{m/s}^2$	V_{fxA}
	Δt

CONNECTIONS

$|\Delta X_A| = 46 - |\Delta X_B|$

$\Delta t_A = \Delta t_B = \Delta t$

B

K	UK
$V_{iBx} = 0$	ΔX_B
$a_{Bx} = .4\ \text{m/s}^2$	V_{fBx}
	Δt

$\Delta X_A = \cancel{V_{iAx}}^{0} \Delta t + \frac{1}{2} a_{Ax} \Delta t^2$ $\qquad$ $\Delta X_B = \cancel{V_{iBx}}^{0} \Delta t + \frac{1}{2} a_{Bx} \Delta t^2$

$$\Delta X_A = \cancel{V_{iAx}}^{0}\Delta t + \frac{1}{2} a_{xA} \Delta t^2$$

$$|\Delta X_A| = \frac{1}{2} a_{xA} \Delta t^2$$

$$\Delta X_B = \cancel{V_{iBx}}^{0}\Delta t + \frac{1}{2} a_{xB} \Delta t^2$$

$$|\Delta X_B| = \frac{1}{2} |a_{xB}| \Delta t^2$$

$$46 - |\Delta X_B| = \frac{1}{2} a_{xA} \Delta t^2$$

$$|\Delta X_B| = 46 - \frac{1}{2} a_{xA} \Delta t^2$$

$$46 - \frac{1}{2} a_{xA} \Delta t^2 = \frac{1}{2} |a_{xB}| \Delta t^2$$

$$46 = \frac{1}{2}(a_{xA} + |a_{xB}|)\Delta t^2$$

$$\Delta t = \sqrt{\frac{2(46)}{a_{xA} + |a_{xB}|}}$$

$$\Delta t = \sqrt{\frac{92}{.6 + .4}}$$

$$\Delta t \simeq 9.59166 \text{ SEC}$$

$$\boxed{\Delta t \simeq 9.59 \text{ SEC}}$$

(b) At the instant they collide, how far has player one ran?

A

(1) 18.4 m
(2) 20.2 m
(3) 24.0 m
(4) 27.6 m
(5) 46.0 m

$$\Delta X_A = \frac{1}{2} a_{xA} \Delta t^2$$

$$= \frac{1}{2}(0.6)\left(\sqrt{92}\right)^2$$

$$\boxed{\Delta X_A \simeq 27.6 \text{ m}}$$

(c) Assuming player one is traveling in the positive x-direction, what is the displacement of player two in the x-direction?

(1) 18.4 m
(2) -18.4 m
(3) 27.6 m
(4) -27.6 m
(5) 46.0 m
(6) -46.0 m

$$|\Delta X_A| = 46 - |\Delta X_B|$$

(3) 27.6 m
(4) -27.6 m
(5) 46.0 m
(6) -46.0 m

$$|\Delta x_A| = 46 - |\Delta x_B|$$

$$|\Delta x_B| = 46 - |\Delta x_A|$$

$$|\Delta x_B| = 18.4\ m$$

$\hat{j}$ $\hat{i}$

BUT $\Delta \vec{r}_B$ $\leftarrow$

SO $\boxed{\Delta x_B = -18.4\ m}$