

Tutorial 03 - Motion 2-3D [ [Edit](#) ]

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## Tutorial 03 - Motion 2-3D

Due: 8:00am on Thursday, March 7, 2013

**Note: You will receive no credit for late submissions.** To learn more, read your instructor's [Grading Policy](#)

## Problem 3.03

**Description:** (a) An object has a position given by  $(\mathbf{r}_{\text{vec}}) = (2.0 \text{ m} + (1.00 \text{ m/s})t) \hat{i} + (3.0 \text{ m} - (2.00 \text{ m/s}^2)t^2) \hat{j}$ , where all quantities are in SI units. What is the magnitude of the acceleration of the object at time  $t = 2.00 \text{ s}$ ?

## Part A

An object has a position given by  $\vec{r} = [2.0 \text{ m} + (5.00 \text{ m/s})t] \hat{i} + [3.0\text{m} - (5.00 \text{ m/s}^2)t^2] \hat{j}$ , where all quantities are in SI units. What is the magnitude of the acceleration of the object at time  $t = 2.00 \text{ s}$ ?

ANSWER:

- 12.0 m/s<sup>2</sup>  
 0.00 m/s<sup>2</sup>  
 8.00 m/s<sup>2</sup>  
 10.0 m/s<sup>2</sup>  
 5.00 m/s<sup>2</sup>

## Exercise 3.3

**Description:** A web page designer creates an animation in which a dot on a computer screen has a position of  $\mathbf{r}_{\text{vec}} = (a_1 + (a_2) t^2) \hat{i} + (a_3) t \hat{j}$ . (a) Find the average velocity of the dot between  $t = 0$  and  $t = 2.0 \text{ s}$ . (...)

A web page designer creates an animation in which a dot on a computer screen has a position of  $\vec{r} = [3.6\text{cm} + (2.4\text{cm/s}^2)t^2]\hat{i} + (4.6\text{cm/s})t\hat{j}$ .

## Part A

Find the average velocity of the dot between  $t = 0$  and  $t = 2.0 \text{ s}$ .

Give your answer as a pair of components separated by a comma. For example, if you think the x component is 3 and the y component is 4, then you should enter 3 , 4. Express your answer using two significant figures.

ANSWER:

$$\vec{v}_{\text{ave}} = 2a_2, a_3 = 4.8, 4.6 \text{ cm/s}$$

## Part B

Find the instantaneous velocity at  $t = 0$ .

Give your answer as a pair of components separated by a comma. For example, if you think the x component is 3 and the y component is 4, then you should enter 3, 4. Express your answer using two significant figures.

ANSWER:

$$\vec{v} = 0, 0, 4.6 \text{ cm/s}$$

### Part C

Find the instantaneous velocity at  $t = 1.0 \text{ s}$ .

Give your answer as a pair of components separated by a comma. For example, if you think the x component is 3 and the y component is 4, then you should enter 3, 4. Express your answer using two significant figures.

ANSWER:

$$\vec{v} = 2a_2 \cdot 1.0, a_3 = 4.8, 4.6 \text{ cm/s}$$

### Part D

Find the instantaneous velocity at  $t = 2.0 \text{ s}$ .

Give your answer as a pair of components separated by a comma. For example, if you think the x component is 3 and the y component is 4, then you should enter 3, 4. Express your answer using two significant figures.

ANSWER:

$$\vec{v} = 2a_2 \cdot 2.0, a_3 = 9.6, 4.6 \text{ cm/s}$$

## Exercise 3.5

**Description:** A jet plane is flying at a constant altitude. At time  $t_1 = 0$  it has components of velocity  $v_x = v_{x1}$ ,  $v_y = v_{y1}$ . At time  $t_2 = t_2$  the components are  $v_x = v_{x2}$ ,  $v_y = v_{y2}$ . (a) For this time interval calculate the average...

A jet plane is flying at a constant altitude. At time  $t_1 = 0$  it has components of velocity  $v_x = 89 \text{ m/s}$ ,  $v_y = 108 \text{ m/s}$ . At time  $t_2 = 35.0 \text{ s}$  the components are  $v_x = 174 \text{ m/s}$ ,  $v_y = 44 \text{ m/s}$ .

### Part A

For this time interval calculate the average acceleration.

Give your answer as a pair of components separated by a comma. For example, if you think the x component is 3 and the y component is 4, then you should enter 3, 4. Express your answer using two significant figures.

ANSWER:

$$\vec{a}_{\text{ave}} = \frac{v_{x2} - v_{x1}}{t_2}, \frac{v_{y2} - v_{y1}}{t_2} = 2.4, -1.8 \text{ m/s}^2$$

**Part B**

Find the magnitude of the average acceleration.

Express your answer using two significant figures.

ANSWER:

$$a_{\text{ave}} = \sqrt{\left(\left(\frac{v_{x2} - v_{x1}}{t_2}\right)^2 + \left(\frac{v_{y2} - v_{y1}}{t_2}\right)^2\right)} = 3.0 \text{ m/s}^2$$

**Part C**

Find the direction of the average acceleration (let the direction be the angle that the vector makes with the +x-axis, measured counterclockwise).

ANSWER:

$$\theta = \frac{\text{atan}\left(\frac{v_{y2} - v_{y1}}{v_{x2} - v_{x1}}\right) \cdot 180}{\pi} = -37.0^\circ$$

$$\text{Also accepted: } 360 + \frac{\text{atan}\left(\frac{v_{y2} - v_{y1}}{v_{x2} - v_{x1}}\right) \cdot 180}{\pi} = 323$$

**Exercise 3.28**

**Description:** The radius of the earth's orbit around the sun (assumed to be circular) is  $1.50 \times 10^8$  (km), and the earth travels around this orbit in 365 days. (a) What is the magnitude of the orbital velocity of the earth in m/s? (b) What is the radial...

The radius of the earth's orbit around the sun (assumed to be circular) is  $1.50 \times 10^8$  km, and the earth travels around this orbit in 365 days.

**Part A**

What is the magnitude of the orbital velocity of the earth in **m/s**?

ANSWER:

$$2.97 \times 10^4 \text{ m/s}$$

**Part B**

What is the radial acceleration of the earth toward the sun?

ANSWER:

$$5.91 \times 10^{-3} \text{ m/s}^2$$

**Part C**

What is the magnitude of the orbital velocity of the planet Mercury (orbit radius =  $5.79 \times 10^7 \text{ km}$ , orbital period = 88.0 days)?

ANSWER:

$$4.78 \times 10^4 \text{ m/s}$$

**Part D**

What is the radial acceleration of the Mercury?

ANSWER:

$$3.95 \times 10^{-2} \text{ m/s}^2$$

**Conceptual Question 3.03**

**Description:** (a) For general projectile motion, when the projectile is at the highest point of its trajectory...

**Part A**

For general projectile motion, when the projectile is at the highest point of its trajectory

ANSWER:

- its velocity and acceleration are both zero.
- the horizontal component of its velocity is zero.
- its acceleration is zero.
- the horizontal and vertical components of its velocity are zero.
- its velocity is perpendicular to the acceleration.

**Exercise 3.21**

**Description:** A man stands on the roof of a building of height  $y_0$  and throws a rock with a velocity of magnitude  $v_0$  at an angle of  $\alpha$  above the horizontal. You can ignore air resistance. (a) Calculate the maximum height above the roof reached by the rock. (b)...

A man stands on the roof of a building of height  $16.3 \text{ m}$  and throws a rock with a velocity of magnitude  $29.0 \text{ m/s}$  at an angle of  $27.4^\circ$  above the horizontal. You can ignore air resistance.

**Part A**

Calculate the maximum height above the roof reached by the rock.

ANSWER:

$$y = \frac{v_0^2 (\sin(\alpha))^2}{2g} = 9.09 \text{ m}$$

**Part B**

Calculate the magnitude of the velocity of the rock just before it strikes the ground.

ANSWER:

$$v = \sqrt{(2gy_0 + v_0^2)} = 34.1 \text{ m/s}$$

**Part C**

Calculate the horizontal distance from the base of the building to the point where the rock strikes the ground.

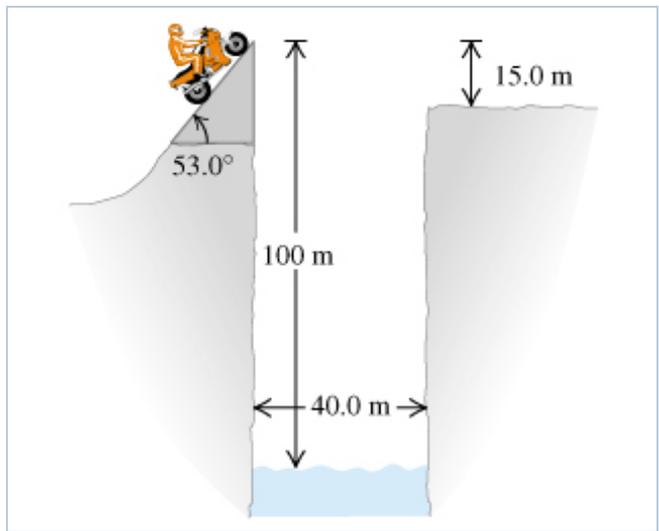
ANSWER:

$$x = \frac{v_0 \cos(\alpha) \left( \sqrt{(2gy_0 + v_0^2 (\sin(\alpha))^2)} + v_0 \sin(\alpha) \right)}{g} = 93.7 \text{ m}$$

**Problem 3.67**

**Description:** A physics professor did daredevil stunts in his spare time. His last stunt was an attempt to jump across a river on a motorcycle (the figure ). The takeoff ramp was inclined at 53.0 degree(s), the river was 40.0 m wide, and the far bank was 15.0 m...

A physics professor did daredevil stunts in his spare time. His last stunt was an attempt to jump across a river on a motorcycle (the figure ). The takeoff ramp was inclined at 53.0 °, the river was 40.0 m wide, and the far bank was 15.0 m lower than the top of the ramp. The river itself was 100 m below the ramp. You can ignore air resistance.



### Part A

What should his speed have been at the top of the ramp to have just made it to the edge of the far bank?

ANSWER:

$$v = 17.8 \text{ m/s}$$

### Part B

If his speed was only half the value found in A, where did he land?

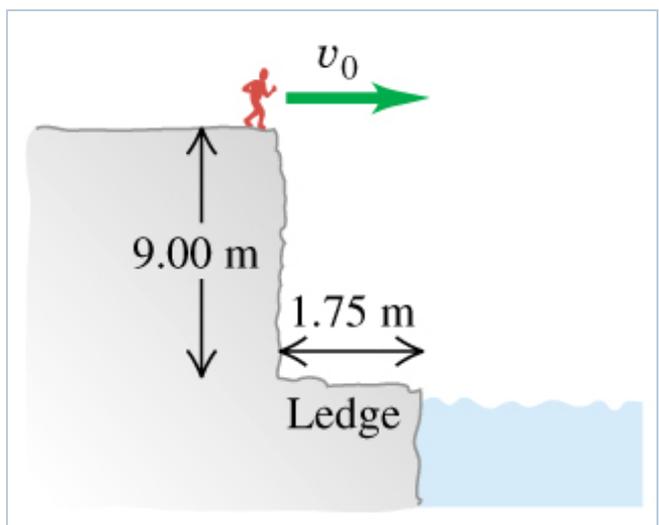
ANSWER:

$$L = 28.4 \text{ m}$$

## Exercise 3.10

**Description:** A daring 510-N swimmer dives off a cliff with a running horizontal leap, as shown in the figure .  
 (a) What must her minimum speed be just as she leaves the top of the cliff so that she will miss the ledge at the bottom, which is 1.75 m wide and 9.00...

A daring 510-N swimmer dives off a cliff with a running horizontal leap, as shown in the figure .



**Part A**

What must her minimum speed be just as she leaves the top of the cliff so that she will miss the ledge at the bottom, which is 1.75 m wide and 9.00 m below the top of the cliff?

ANSWER:

$$v_0 = 1.29 \text{ m/s}$$

**Exercise 3.36**

**Description:** A river flows due south with a speed of 2.0 m/s. A man steers a motorboat across the river. The river is 800 m wide. (a) In which direction should the motorboat head in order to reach a point on the opposite bank directly east from the starting...

A river flows due south with a speed of 2.0 m/s. A man steers a motorboat across the river. The river is 800 m wide.

**Part A**

In which direction should the motorboat head in order to reach a point on the opposite bank directly east from the starting point? (The boat's speed relative to the water is 4.2 m/s.)

**Express your answer using two significant figures.**

ANSWER:

$$\theta = 28^\circ \text{ north of east}$$

**Part B**

What is the velocity of the boat relative to the earth?

**Express your answer using two significant figures.**

ANSWER:

$$v = 3.7 \text{ m/s}$$

**Part C**

How much time is required to cross the river?

ANSWER:

$$t = 217 \text{ s}$$

**Problem 3.81**

**Description:** An airplane pilot sets a compass course due west and maintains an airspeed of  $v$ . After flying for a time of  $t$ , she finds herself over a town a distance  $x$  west and a distance  $y$  south of her starting point. (a) Find the magnitude of the wind velocity. ...

An airplane pilot sets a compass course due west and maintains an airspeed of  $210 \text{ km/h}$ . After flying for a time of  $0.480 \text{ h}$ , she finds herself over a town a distance  $119 \text{ km}$  west and a distance  $21 \text{ km}$  south of her starting point.

### Part A

Find the magnitude of the wind velocity.

ANSWER:

$$v = \sqrt{\left(\frac{y}{t}\right)^2 + \left(\frac{x - vt}{t}\right)^2} = 57.9 \text{ km/h}$$

### Part B

Find the direction of the wind velocity.

**Express your answer as an angle measured south of west**

ANSWER:

$$\theta = \frac{\text{atan}\left(\frac{y}{x - vt}\right) \cdot 180}{\pi} = 49.1^\circ \text{ south of west}$$

### Part C

If the wind velocity is  $44 \text{ km/h}$  due south, in what direction should the pilot set her course to travel due west? Use the same airspeed of  $210 \text{ km/h}$ .

**Express your answer as an angle measured north of west**

ANSWER:

$$\theta = \frac{\text{asin}\left(\frac{v_w}{v}\right) \cdot 180}{\pi} = 12.1^\circ \text{ north of west}$$