AP Physics 2 **Wynne**
Summer assignment

This assignment is due and must be turned in the **FIRST** day of school. Failure to do so at that time will result in reduction of points according to the campus late work policy.

The purpose of this assignment is to allow you to revisit some of the math involved with physics and introduce some new concepts with an informal lab (i-Lab). While these problems do not cover the entire scope of applied physics in the course, if you can do the math involved in these, you should be skilled enough to work the problems in the AP book. You must have a very good grasp of Algebra 2, and Pre-Calculus to be successful. While you might be able to gain these skills during the course, it will be to your advantage to already have mastered them. If you are a little fuzzy on how to approach these, there are tutorials attached at the end from Holt Physics Resources.

Answer Check

A:	1)	x=159m; v = 20 m/s
	2)	d=4.9m; θ = 0° due E
B.	1)	θ = 32.2° N of W; x = 140 cm
	2)	x = 5m; y = 8.66m
	3)	x = 53.7° ; x = 8.3 m
C.	1)	d = 216.5m; θ = 30.01.2° N of E
	2)	y = 10700m; x = 26900m; d= 28900m; θ = 21.0° above the horizontal
	3)	d = 1320 lm; 3.5° E of N
D.	1)	170m high
E.	1)	132km/h; 72.4° N of E
	2)	1.7h

Solve these problems **NEATLY** on notebook paper. Include appropriate diagrams. If the work and/or the answer are not legible, it will be considered wrong. I want to be able to clearly follow the process by which you attained the answer. To that end, if you are especially messy in your problem solving, you may need to do a rough draft before a final version.
BOX the answer. You may also check your answer to see if it is correct on the accompanying answer page.

SET A

1. An ostrich cannot fly, but it is able to run fast. Suppose an ostrich runs east for 7.95 s and then runs 161 m south, so that the magnitude of the ostrich's resultant displacement is 226 m. Calculate the magnitude of the ostrich's eastward component and its running speed.
2. The pronghorn antelope, found in North America, is the best long distance runner among mammals. It has been observed to travel at an average speed of more than 55 km/h over a distance of 6.0 km. Suppose the antelope runs a distance of 5.0 km in a direction 11.5° north of east, turns, and then runs 1.0 km south. Calculate the resultant displacement.

SET B

1. A common flea can jump a distance of 33 cm. Suppose a flea makes five jumps of this length in the northwest direction. If the flea's northward displacement is 88 cm, what is the flea's westward displacement.
2. The longest snake ever found was a python that was 10.0 m long. Suppose a coordinate system large enough to measure the python's length is drawn on the ground. The snake's tail is then placed at the origin and the snake's body is stretched so that it makes an angle of 60.0° with the positive *x*-axis. Find the *x* and *y* coordinates of the snake's head. (Hint: he *y* coordinate is positive.)
3. A South-African sharp-nosed frog set a record for a triple jump by traveling a distance of 10.3 m. Suppose the frog starts from the origin of a coordinate system and lands at a point whose coordinate on the *y*-axis is equal to −6.10 m. What angle does the vector of is placement make with the negative *y*-axis? Calculate the *x* component of the frog.

SET C

1. For six weeks in 1992, Akira Matsushima, from Japan, rode a unicycle more than 3000 mi across the United States. Suppose Matsushima is riding through a city. If he travels 250.0 m east on one street, then turns counterclockwise through a 120.0° angle and proceeds 125.0 m northwest along a diagonal street, what is his resultant displacement?
2. In 1976, the Lockheed SR-71A *Blackbird* set the record speed for any airplane: 3.53×10^3 km/h. Suppose you observe this plane ascending at this speed. For 20.0 s, it flies at an angle of 15.0° above the horizontal, then for another 10.0 s its angle of ascent is increased to 35.0°. Calculate the plane's total gain in altitude, its total horizontal displacement, and its resultant displacement.
3. The fastest propeller-driven aircraft is the Russian TU-95/142, which can reach a maximum speed of 925 km/h. For this speed, calculate the plane's resultant displacement if it travels east for 1.50 h, then turns 135° northwest and travels for 2.00 h.

SET D

1. The longest shot on a golf tournament was made by Mike Austin in 1974. The ball went a distance of 471 m. Suppose the ball was shot horizontally off a cliff at 80.0 m/s. Calculate the height of the cliff.

SET E

1. In 1933, a storm occurring in the Pacific Ocean moved with speeds reaching a maximum of 126 km/h. Suppose a storm is moving north at this speed. If a gull flies east through the storm with a speed of 40.0 km/h relative to the air, what is the velocity of the gull relative to Earth?
2. George V Coast in Antarctica is the windiest place on Earth. Wind speeds there can reach 3.00×10^2 km/h. If a research plane flies against the wind with a speed of 4.50×10^2 km/h relative to the wind, how long does it take the plane to fly between two research stations that are 250 km apart?

i-Lab: Measuring the rate of flow for a fluid.

To do the following lab, you may need to do some informal research to determine volume, etc.

Measurements:
Using your kitchen faucet, garden hose, etc. and a container of known volume, measure the amount of water to flow during a defined period of time.
Measure the diameter of the outlet.
Make measurements for at least two different outlets of different diameters.
Calculations:
Using your knowledge of geometry and basic Physics 1, calculate the volumetric rate of flow of the water coming out of the outlet.
Then, calculate the linear speed of the water as it comes through the out let. Show all of your calculations.

We observe: What did you observe as a result of your data collection?

Because: Why do you think that happens this way?

So that: What predictions could you make regarding the flow speed of water in a stream as it changes width, or of air in AC ducts as hey change size?

Error:
Look for sources of error. BUT remember that "inaccurate measurements" and "human error" should be counted as sources of error because each of those is avoidable by being careful and deliberate in doing an experiment. Carelessness is not an acceptable option.

Holt Physics

Problem 3A

FINDING RESULTANT MAGNITUDE AND DIRECTION

PROBLEM

Cheetahs are, for short distances, the fastest land animals. In the course of a chase, cheetahs can also change direction very quickly. Suppose a cheetah runs straight north for 5.0 s, quickly turns, and runs 3.00×10^2 m west. If the magnitude of the cheetah's resultant displacement is 3.35×10^2 m, what is the cheetah's displacement and velocity during the first part of its run?

SOLUTION

1. DEFINE

Given:

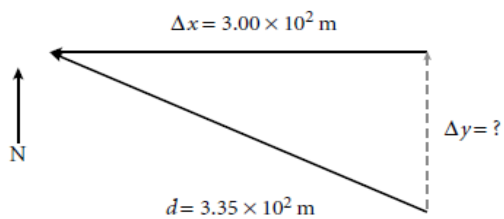
$\Delta t_1 = 5.0$ s

$\Delta x = 3.00 \text{ s} \times 10^2$ m

$d = 3.35 \times 10^2$ m

Unknown: $\Delta y = ?$ $\quad v_y = ?$

Diagram:



2. PLAN

Choose the equation(s) or situation: Use the Pythagorean theorem to subtract one of the displacements at right angles from the total displacement, and thus determine the unknown component of displacement.

$$d^2 = \Delta x^2 + \Delta y^2$$

Use the equation relating displacement to constant velocity and time, and use the calculated value for Δy and the given value for Δt to solve for v.

$$\Delta v = \frac{\Delta y}{\Delta t}$$

Rearrange the equation(s) to isolate the unknown(s):

$$\Delta y^2 = d^2 - \Delta x^2$$

$$\Delta y = \sqrt{d^2 - \Delta x^2}$$

$$v_y = \frac{\Delta y}{\Delta t}$$

3. CALCULATE

Substitute the values into the equation(s) and solve: Because the value for Δy is a displacement magnitude, only the positive root is used ($\Delta y > 0$).

$$\Delta y = \sqrt{(3.35 \times 10^2 \text{ m})^2 - (3.00 \times 10^2 \text{ m})^2}$$

$$= \sqrt{1.12 \times 10^5 \text{ m}^2 - 9.00 \times 10^4 \text{ m}^2}$$

$$= \sqrt{2.2 \times 10^4 \text{ m}}$$

$$= \boxed{1.5 \times 10^2 \text{ m, north}}$$

$$v_y = \frac{1.5 \times 10^2 \text{ m}}{5.0 \text{ s}} = \boxed{3.0 \times 10^1 \text{ m/s, north}}$$

4. EVALUATE

The cheetah has a top speed of 30 m/s, or 107 km/h. This is equal to about 67 miles/h.

Holt Physics

Problem 3B

RESOLVING VECTORS

PROBLEM

Certain iguanas have been observed to run as fast as 10.0 m/s. Suppose an iguana runs in a straight line at this speed for 5.00 s. The direction of motion makes an angle of 30.0° to the east of north. Find the value of the iguana's northward displacement.

SOLUTION

1. DEFINE

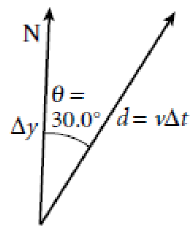
Given: $v = 10.0$ m/s

$t = 5.00$ s

$\theta = 30.0°$

Unknown: $\Delta y = ?$

Diagram:



2. PLAN

Choose the equation(s) or situation: The northern component of the vector is equal to the vector magnitude times the cosine of the angle between the vector and the northward direction.

$$\Delta y = d(\cos \theta)$$

Use the equation relating displacement with constant velocity and time, and substitute it for d in the previous equation.

$$d = v\Delta t$$

$$\Delta y = v\Delta t(\cos \theta)$$

3. CALCULATE

Substitute the values into the equation(s) and solve:

$$\Delta y = \left(10.0\,\frac{\text{m}}{\text{s}}\right)(5.00\text{ s})(\cos 30.0°)$$

$$= \boxed{43.3\text{ m, north}}$$

4. EVALUATE

The northern component of the displacement vector is smaller than the displacement itself, as expected.

Holt Physics

Problem 3C

ADDING VECTORS ALGEBRAICALLY

PROBLEM

The southernmost point in the United States is called South Point, and is located at the southern tip of the large island of Hawaii. A plane designed to take off and land in water leaves South Point and flies to Honolulu, on the island of Oahu, in three separate stages. The plane first flies 83.0 km at 22.0° west of north from South Point to Kailua Kona, Hawaii. The plane then flies 146 km at 21.0° west of north from Kailua Kona to Kahului, on the island of Maui. Finally, the plane flies 152 km at 17.5° north of west from Kahului to Honolulu. What is the plane's resultant displacement?

SOLUTION

1. DEFINE

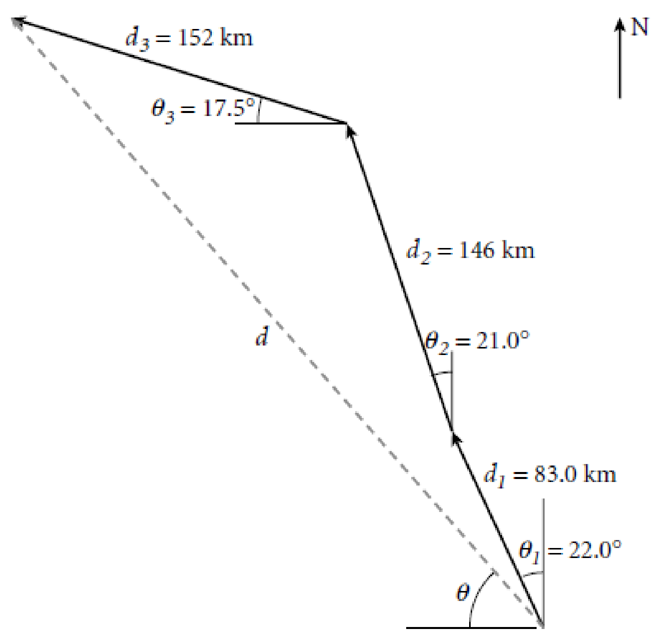
Given: $d_1 = 83.0$ km $\quad \theta_1 = 22.0°$ west of north

$d_2 = 146$ km $\quad \theta_2 = 21.0°$ west of north

$d_3 = 152$ km $\quad \theta_3 = 17.5°$ north of west

Unknown: $d = ?$ $\quad \theta = ?$

Diagram:



2. PLAN

Choose the equation(s) or situation: Express the components of each vector in terms of sine or cosine functions.

$\Delta x_1 = d_1 (\sin \theta_1) \qquad \Delta y_1 = d_1 (\cos \theta_1)$

$\Delta x_2 = d_2 (\sin \theta_2) \qquad \Delta y_2 = d_2 (\cos \theta_2)$

$\Delta x_3 = d_3 (\cos \theta_3) \qquad \Delta y_3 = d_3 (\sin \theta_3)$

Note that the angles θ_1 and θ_2 are with respect to the y axis (north), and so the x components are in terms of sin θ. Write the equations for Δx_{tot} and Δy_{tot}, the components of the total displacement.

$$\Delta x_{tot} = \Delta x_1 + \Delta x_2 + \Delta x_3$$
$$= d_1 (\sin \theta_1) + d_2(\sin \theta_2) + d_3 (\cos \theta_3)$$
$$\Delta y_{tot} = \Delta y_1 + \Delta y_2 + \Delta y_3$$
$$= d_1 (\cos \theta_1) + d_2(\cos \theta_2) + d_3 (\sin \theta_3)$$

Use the components of the total displacement, the Pythagorean theorem, and the tangent function to calculate the total displacement.

$$d = \sqrt{(\Delta x_{tot})^2 + (\Delta y_{tot})^2}$$
$$\theta = \tan^{-1}\left(\frac{\Delta y_{tot}}{\Delta x_{tot}}\right)$$

3. CALCULATE **Substitute the values into the equation(s) and solve:**

$$\Delta x_{tot} = (83.0 \text{ km})(\sin 22.0°) + (146 \text{ km})(\sin 21.0°) + (152 \text{ km})(\cos 17.5°)$$
$$= 31.1 \text{ km} + 52.3 \text{ km} + 145 \text{ km}$$
$$= 228 \text{ km}$$
$$\Delta y_{tot} = (83.0 \text{ km})(\cos 22.0°) + (146 \text{ km})(\cos 21.0°) + (152 \text{ km})(\sin 17.5°)$$
$$= 259 \text{ km}$$
$$d = \sqrt{(228 \text{ km})^2 + (259 \text{ km})^2} = \sqrt{5.20 \times 10^4 \text{ km}^2 + 6.71 \times 10^4 \text{ km}^2} = \sqrt{11.91 \times 10^4 \text{ km}^2}$$
$$= \boxed{345.1 \text{ km}}$$
$$\theta = \tan^{-1}\left(\frac{259 \text{ km}}{228 \text{ km}}\right) = \boxed{48.6° \text{ north of west}}$$

4. EVALUATE If the diagram is drawn to scale, compare the calculated results to the drawing. The length of the drawn resultant is fairly close to the scaled magnitude for *d*, while the angle appears to be slightly greater than 45°.

Holt Physics

Problem 3D

PROJECTILES LAUNCHED HORIZONTALLY

PROBLEM

A movie director is shooting a scene that involves dropping s stunt dummy out of an airplane and into a swimming pool. The plane is 10.0 m above the ground, traveling at a velocity of 22.5 m/s in the positive *x* direction. The director wants to know where in the plane's path the dummy should be dropped so that it will land in the pool. What is the dummy's horizontal displacement?

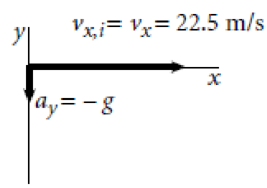
SOLUTION

1. DEFINE

Given: $\Delta y = -10.0$ m $\quad g = 9.81$ m/s^2 $\quad v_x = 22.5$ m/s

Unknown: $\Delta t = ?\quad \Delta x = ?$

Diagram: The initial velocity vector of the stunt dummy only has a horizontal component. Choose the coordinate system oriented so that the positive *y* direction points upward and the positive *x* direction points to the right.



2. PLAN

Choose the equation(s) or situation: The dummy drops with no initial vertical velocity. Because air resistance is neglected, the dummy's horizontal velocity remains constant.

$$\Delta y = -\tfrac{1}{2} g \Delta t^2$$

$$\Delta x = v_x \Delta t$$

Rearrange the equation(s) to isolate the unknown(s):

$$\frac{2\Delta y}{-g} = \Delta t^2$$

$$\Delta t = \sqrt{\frac{2\Delta y}{-g}} \text{ where } \Delta y \text{ is negative}$$

3. CALCULATE

First find the time it takes for the dummy to reach the ground.

$$\Delta t = \sqrt{\frac{2\Delta y}{-g}} = \frac{(2)(-10.0 \text{ m})}{-9.81 \text{ m/s}^2} = 1.43 \text{ s}$$

Find out how far horizontally the dummy can travel during this period of time.

$$\Delta x = v_x \Delta t = (22.5 \text{ m/s})(1.43 \text{ s})$$

$$= \boxed{\Delta x\ 32.2 \text{ m}}$$

4. EVALUATE

The stunt dummy will have to drop from the plane when the plane is at a horizontal distance of 32.2 m from the pool. The distance is within the correct order of magnitude, given the other values in this problem.

Problem 3E

PROJECTILES LAUNCHED AT AN ANGLE

PROBLEM

The narrowest strait on earth is Seil Sound in Scotland, which lies between the mainland and the island of Seil. The strait is only about 6.0 m wide. Suppose an athlete wanting to jump "over the sea" leaps at an angle of 35° with respect to the horizontal. What is the minimum initial speed that would allow the athlete to clear the gap? Neglect air resistance.

SOLUTION

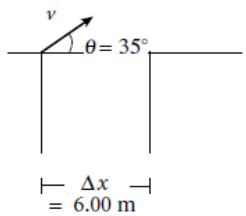
1. DEFINE **Given:** $\Delta x = 6.0 \text{ m}$

$\theta = 35°$

$g = 9.81 \text{ m/s}$

Unknown: $v_i = ?$

2. PLAN **Diagram:**



Choose the equation(s) or situation: The horizontal component of the athlete's velocity, v_x, is equal to the initial speed multiplied by the cosine of the angle, θ, which is equal to the magnitude of the horizontal displacement, Δx, divided by the time interval required for the complete jump.

$$v_x = v_i \cos\theta = \frac{\Delta x}{\Delta t}$$

At the midpoint of the jump, the vertical component of the athlete's velocity, v_y, which is the upward vertical component of the initial velocity, $v_i \sin\theta$, minus the downward component of velocity due to free-fall acceleration, equals zero. The time required for this to occur is half the time necessary for the total jump.

$$v_y = v_i \sin\theta - g\left(\frac{\Delta t}{2}\right) = 0$$

$$v_i \sin\theta = \frac{g\Delta t}{2}$$

Rearrange the equation(s) to isolate the unknown(s): Express Δt in the second equation in terms of the displacement and velocity component in the first equation.

$$v_i \sin\theta = \frac{g}{2}\left(\frac{\Delta x}{v_i \cos\theta}\right)$$

$$v_i^2 = \frac{g\Delta x}{2 \sin\theta \cos\theta}$$

$$v_i = \sqrt{\frac{g\Delta x}{2 \sin\theta \cos\theta}}$$

3. CALCULATE **Substitute the values into the equation(s) and solve:** Select the positive root for v_i.

$$v_i = \sqrt{\frac{\left(9.81 \frac{\text{m}}{\text{s}^2}\right)(6.0 \text{ m})}{(2)(\sin 35°)(\cos 35°)}} = \boxed{7.9 \frac{\text{m}}{\text{s}}}$$

4. EVALUATE By substituting the value for v_i into the original equations, you can determine the time for the jump to be completed, which is 0.92 s. From this, the height of the jump is found to equal 1.0 m.

Holt Physics

Problem 3F

RELATIVE VELOCITY

PROBLEM

The world's fastest current is in Slingsby Channel, Canada, where the speed of the water reaches 30.0 km/h. Suppose a motorboat crosses the channel perpendicular to the bank at a speed of 18.0 km/h relative to the bank. Find the velocity of the motorboat relative to the water.

SOLUTION

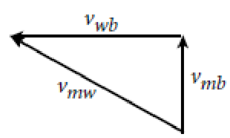
1. DEFINE

Given: $\mathbf{v_{wb}}$ = 30.0 km/h along the channel (velocity of the *water, w,* with respect to the *bank, b)*

$\mathbf{v_{mb}}$ = 18.0 km/h perpendicular to the channel (velocity of the *motorboat, m,* with respect to the *bank, b)*

Unknown: $\mathbf{v_{mw}} = ?$

Diagram:



2. PLAN

Choose the equation(s) or situation: From the vector diagram, the resultant vector (the velocity of the motorboat with respect to the bank, $\mathbf{v_{mb}}$) is equal to the vector sum of the other two vectors, one of which is the unknown.

$$\mathbf{v_{mw}} = \mathbf{v_{mb}} + \mathbf{v_{wb}}$$

Use the Pythagorean theorem to calculate the magnitude of the resultant velocity, and use the tangent function to find the direction. Note that because the vectors $\mathbf{v_{mb}}$ and $\mathbf{v_{wb}}$ are perpendicular to each other, the product that results from multiplying one by the other is zero. The tangent of the angle between $\mathbf{v_{mb}}$ and $\mathbf{v_{mw}}$ is equal to the ratio of the magnitude of $\mathbf{v_{wb}}$ to the magnitude of $\mathbf{v_{mb}}$.

$$v_{mw}^2 = v_{mb}^2 + v_{wb}^2$$

$$\tan\theta = \frac{v_{wb}}{v_{mb}}$$

Rearrange the equation(s) to isolate the unknown(s):

$$v_{mw} = \sqrt{v_{mb}^2 + v_{wb}^2}$$

$$\theta = \tan^{-1}\left(\frac{v_{wb}}{v_{mb}}\right)$$

3. CALCULATE

Substitute the values into the equation(s) and solve: Choose the positive root for v_{mw}.

$$v_{mw} = \sqrt{\left(18.0\frac{\text{km}}{\text{h}}\right)^2 + \left(30.0\frac{\text{km}}{\text{h}}\right)^2} = \boxed{35.0\frac{\text{km}}{\text{h}}}$$

The angle between v_{mb} and v_{mw} is as follows:

$$\theta = \tan^{-1}\left(\frac{30.0\frac{\text{km}}{\text{h}}}{18.0\frac{\text{km}}{\text{h}}}\right) = \boxed{\text{59.0° away from the oncoming current}}$$

4. EVALUATE

The motorboat must move in a direction 59° with respect to $\mathbf{v_{mb}}$ and against the current, and with a speed of 35.0 km/h in order to move 18.0 km/h perpendicular to the bank.