Answers to even-numbered problems

Username: PHYS1020

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FALL 2007

Welcome to Physics 1020!

Instructors | Required Materials | Schedule | Policies/Evaluation | Suggested Problems | Formula Sheet

Answers to Even-Numbered Problems

Mastering Physics Assignment # 1

Information on "Mastering Physics"

Combining Mastering Physics with Mastering Chemistry

GENERAL PHYSICS I: PHYS 1020

Schedule - Fall 2007
(lecture schedule is approximate)

3	M	17	5			Errors Lecture
	W	19	6	Chapter 3	Kinematics in two dimensions	
	F	21	7			
4	M	24	8			Experiment 1: Measurement of Length and Mass
	W	26	9	Chapter 4	Forces and Newton's laws	
	F	28	10			
5	M	Oct 1	11			Tutorial and Test 1 (chapters 1, 2, 3)
	W	3	12	Chapter 5	Uniform circular motion	
	F	5	13			

Week of September 24

Experiment 1, measurement of length and mass

Week of October 1

Tutorial and test 1 on chapters 1, 2, 3

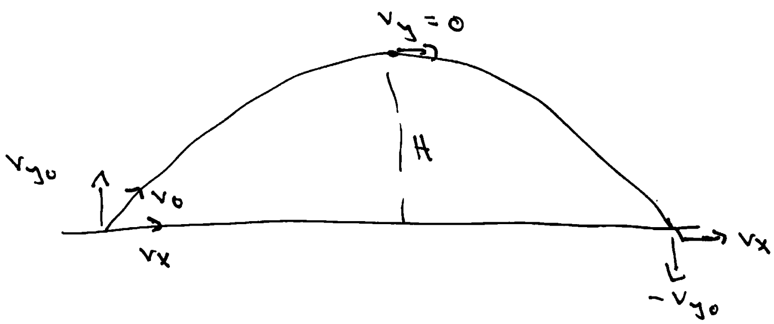
Projectile Motion

3.C5: A tennis ball is hit upward into the air and moves along an arc.

Neglecting air resistance, where along the arc is the speed of the ball

a) a minimum?

b) a maximum?



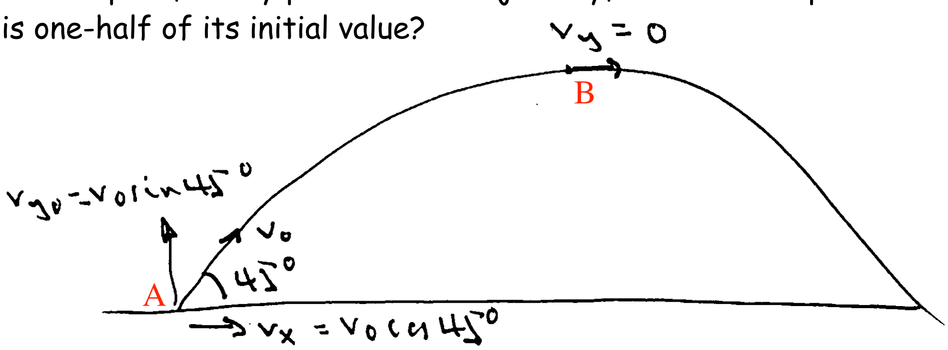
v_x is constant, v_y varies

$v^2 = v_x^2 + v_y^2$

$v_y = 0$ at highest point, and so, the smallest v...

3.C11: A leopard springs upward at a 45⁰ angle and then falls back to the ground.

Does the leopard, at any point on its trajectory, ever have a speed that is one-half of its initial value?



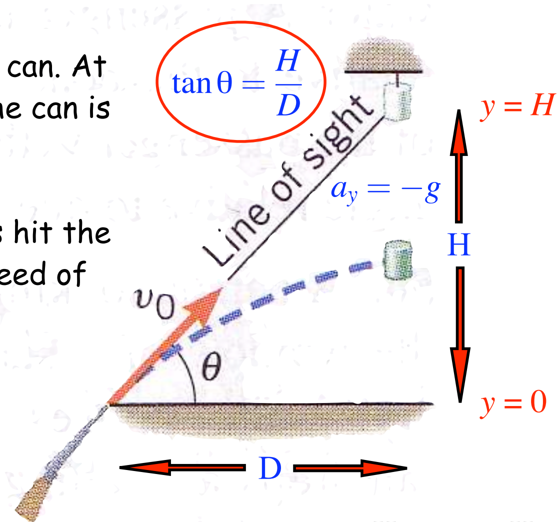
At any point: $v = \sqrt{v_x^2 + v_y^2}$, and $v_x = v_0 \cos 45° = v_0/\sqrt{2}$

At B: $v_y = 0$, so $v = v_x = v_0/\sqrt{2} \approx 0.7 v_0$, which is the smallest v

→ The speed never falls to half its initial value.

3.46: A rifle is aimed at a small can. At the instant the rifle is fired, the can is released.

Show that the bullet will always hit the can, regardless of the initial speed of the bullet.



Bullet:

$$y_b = v_{0y}t - \frac{1}{2}gt^2$$

Can:

$$y_c = H - \frac{1}{2}gt^2$$

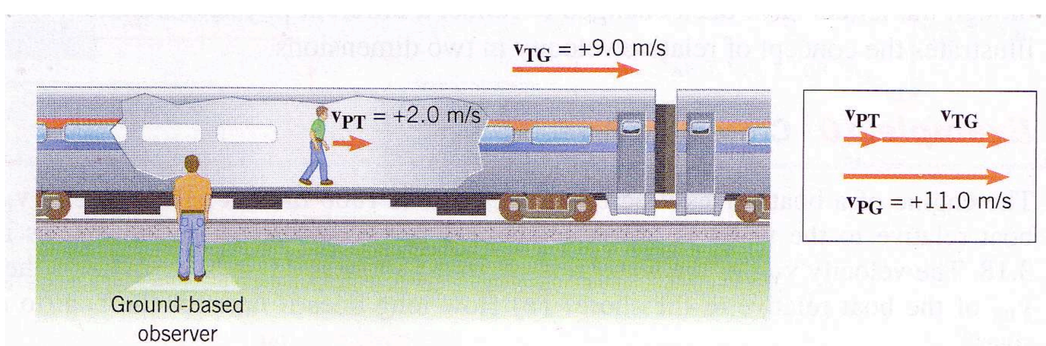
$$x = v_x t = v_0 \cos\theta \frac{H}{v_0 \sin\theta} = \frac{H}{\tan\theta}$$

$$x = D$$

Bullet and can meet when $y_b = y_c$:

$$v_{0y}t - \frac{1}{2}gt^2 = H - \frac{1}{2}gt^2 \rightarrow t = \frac{H}{v_{0y}}$$

Relative Velocity



$\vec{v}_{PT} =$ velocity of passenger relative to train

$\vec{v}_{TG} =$ velocity of train relative to ground

$$\vec{v}_{PG} = \vec{v}_{PT} + \vec{v}_{TG}$$

$\vec{v}_{PG} =$ velocity of passenger relative to ground

Relative Velocity

If: A moves at velocity $\vec{v}_A$ (relative to the ground)

and: B moves at velocity $\vec{v}_B$ (relative to the ground)

then, the velocity of ***B* relative to *A*** is:

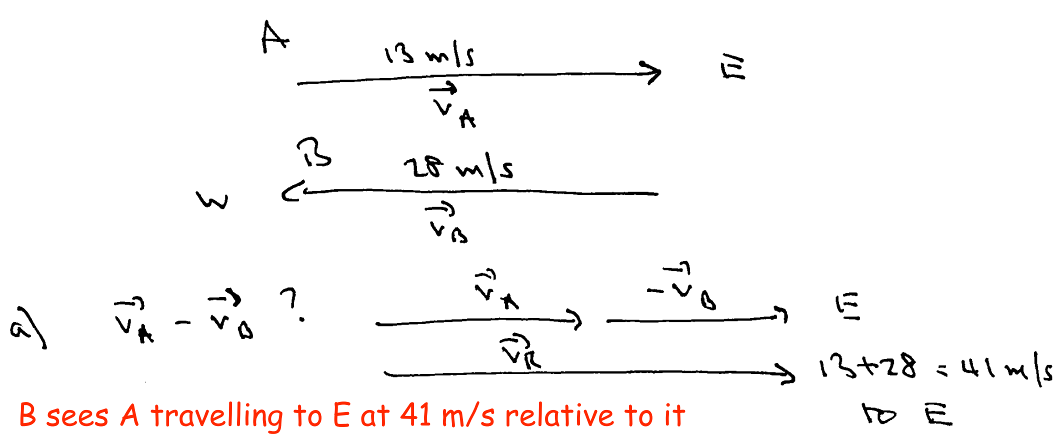
$$\boxed{\vec{v}_{BA} = \vec{v}_B - \vec{v}_A}$$

This is the velocity of B as seen by A.

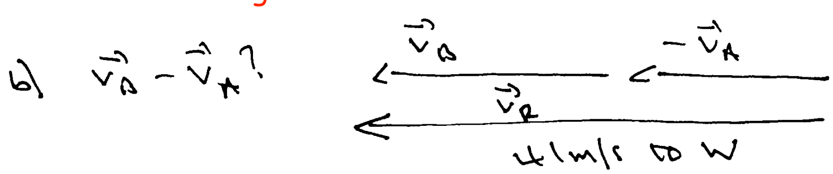
3.51/47: Two trains are passing each other. Train A is moving east at 13 m/s, train B is travelling west at 28 m/s.

a) What is the velocity of train A relative to train B?

b) What is the velocity of train B relative to train A?

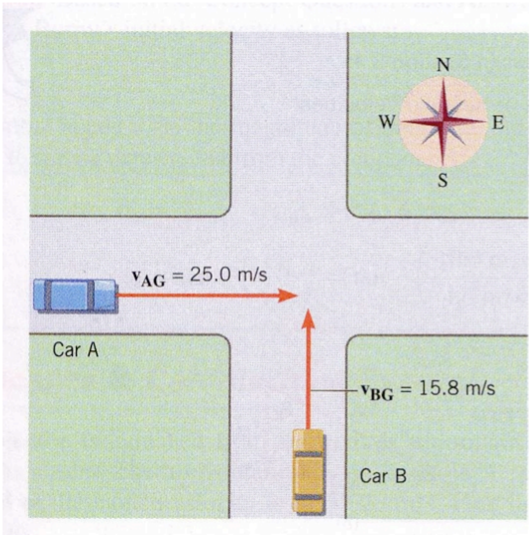


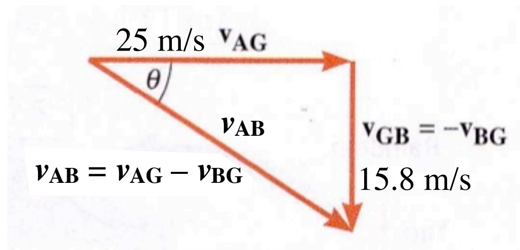
B sees A travelling to E at 41 m/s relative to it



Relative Velocity

Velocity of car A relative to car B is $\vec{v}_{AB} = \vec{v}_{AG} - \vec{v}_{BG}$





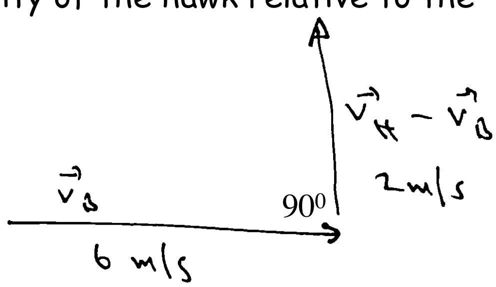
$$v_{AB}^2 = v_{AG}^2 + v_{BG}^2 = 25^2 + 15.8^2$$
$$v_{AB} = 29.6 \text{ m/s}$$

$$\tan\theta = 15.8/25,\ \theta = 32.3^\circ$$

Relative to B, A is travelling at 29.6 m/s at 32.3^0 south of east

3.53: A hot air balloon is moving relative to the ground at 6 m/s due east. A hawk flies at 2 m/s due north **relative to the balloon**. What is the velocity of the hawk relative to the ground?

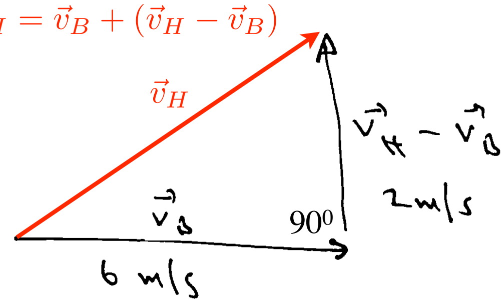
Break into components, or...



$$\vec{v}_H = \vec{v}_B + (\vec{v}_H - \vec{v}_B)$$

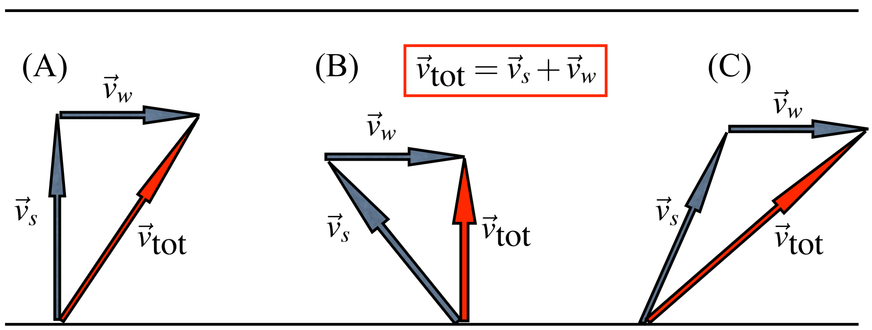
$$v_H = \sqrt{6^2 + 2^2} = 6.3 \text{ m/s}$$

$$\tan\theta = \frac{2}{6},\ \theta = 18.4^\circ \text{ N of E}$$



Clickers!

3.C16: Strategies for swimming across the river in the shortest time. Which is fastest? The swimmers swim at the same speed v_s relative to the water. The water flows at speed v_w.

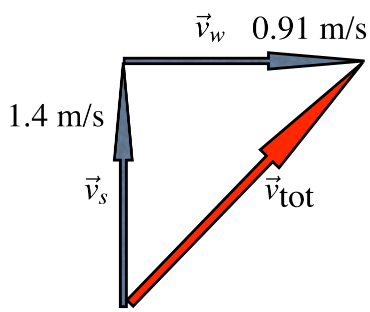


(A) Head straight across, get carried downstream

(B) Head upstream to end at closest point on far bank

(C) Head downstream to take advantage of the current

Relative Velocity

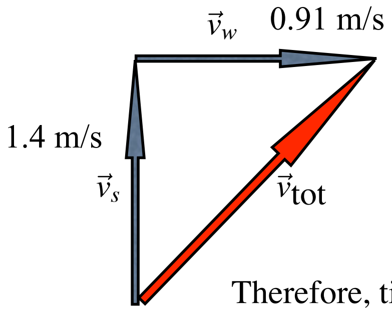


$$\vec{v}_{tot} = \vec{v}_s + \vec{v}_w$$

3.47/51: A swimmer swims directly across a river that is 2.8 km wide. He can swim at 1.4 m/s in still water (v_s), i.e. at 1.4 m/s relative to the water. The river flows at 0.91 m/s (v_w), i.e. at 0.91 m/s relative to the riverbank.

How long to cross the river?
Where does he end up on the other bank?

Relative Velocity contd



As he's swimming directly across the river, his speed toward the other bank is 1.4 m/s.

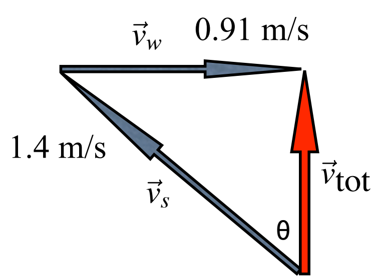
Therefore, time to cross the river is $\dfrac{2800 \text{ m}}{1.4 \text{ m/s}} = 2000 \text{ s}$

In this time, the current will carry him downstream by:

$$(0.91 \text{ m/s}) \times (2000 \text{ s}) = 1820 \text{ m}$$

Relative Velocity contd

Alternative strategy: he heads upstream a little so as to swim directly across the river - the most direct route.



$$\vec{v}_{tot} = \vec{v}_s + \vec{v}_w$$

Pythagoras:

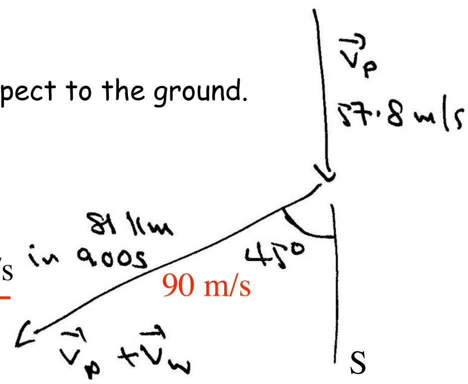
$$v_s^2 = v_w^2 + v_{tot}^2$$

So, $v_{tot} = \sqrt{v_s^2 - v_w^2} = \sqrt{1.4^2 - 0.91^2} = 1.064 \text{ m/s}$

Takes $\dfrac{2800 \text{ m}}{1.064 \text{ m/s}} =$ 2630 s to cross the river $\quad \sin\theta = \dfrac{0.91}{1.4} \rightarrow \theta = 41^\circ$

3.69/57: An aircraft is headed due south with a speed of 57.8 m/s relative to still air. Then, for 900 s a wind blows the plane so that it moves in a direction 45^0 west of south, even though the plane continues to point due south. The plane travels 81 km with respect to the ground in this time.

Determine the velocity of the wind with respect to the ground.



To south:

$$(v_p)_S + (v_w)_S = 90\cos 45^\circ$$
$$57.8 + (v_w)_S = 63.64 \;\longrightarrow\; \underline{(v_w)_S = 5.84 \text{ m/s}}$$

To west:

$$(v_p)_W + (v_w)_W = 90\sin 45^\circ$$
$$0 + (v_w)_W = 63.64 \;\longrightarrow\; \underline{(v_w)_W = 63.64 \text{ m/s}}$$

$$v_w = \sqrt{5.84^2 + 63.64^2} = 63.9 \text{ m/s} \qquad \tan\theta_w = \frac{63.84}{5.84} \;\longrightarrow\; \theta_w = 84.8^\circ$$

west of south

Chapter 3 Summary

- The laws of motion can be applied separately to motions in x and y (negligible air resistance).
- The time for a projectile to move up and down is the same as the time for it to sideways.
- Relative velocity is an application of the subtraction of vectors covered in chapter 1.
- If A travels at $\vec{v}_A$ and B travels at $\vec{v}_B$ the velocity of B relative to A is $\vec{v}_B - \vec{v}_A$