Announcements

1. Tentatively changed schedule; postponing first exam – Tuesday, Sept. 30th
2. HW 1 and HW 2 WebAssign sets due today before midnight
3. Summary of 1-dimensional motion relationships
4. Today's lecture – vectors
   a. What are they and what do they have to do with us?
   b. How to combine them – adding and subtracting
   c. How to multiply them & why would we want to

Displacement, velocity, and acceleration:

1. Displacement $$x(t) = \int_0^t dt' v(t') = \int_0^t dt' \int_0^{t'} dt'' a(t'')$$
2. Velocity $$v(t) = \frac{dx(t)}{dt} = \int_0^t dt' a(t')$$
3. Acceleration $$a(t) = \frac{dv(t)}{dt}$$

Special case of constant acceleration: $a(t) = a_0$
(assume that initial time is $t=0s$)

$v(t) = v_0 + a_0 t$

$x(t) = x_0 + v_0 t + \frac{1}{2} a_0 t^2 = x_0 + \frac{1}{2} (v_0 + v(t)) t$

$(v(t))^2 = (v_0)^2 + 2 a_0 (x(t) - x_0)$

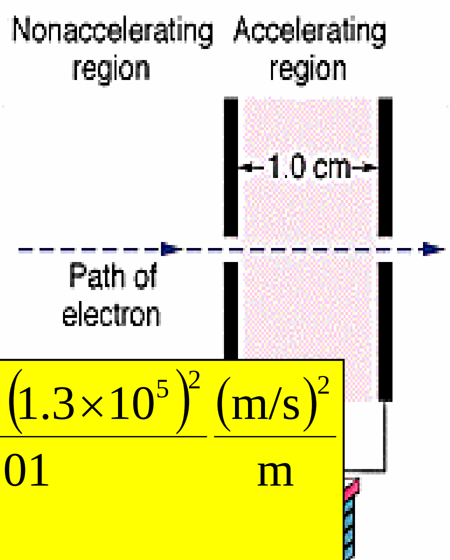
$$v(t) = v_0 + a_0\, t$$

$$x(t) = x_0 + v_0\, t + \tfrac{1}{2}\, a_0\, t^2 = x_0 + \tfrac{1}{2}\,(v_0 + v(t))\, t$$

$$(v(t))^2 = (v_0)^2 + 2\, a_0\, (x(t) - x_0)$$

5. HRW6 2.P.029. [52220] An electron with initial velocity $v_0 = 1.3 \times 10^5$ m/s enters a region 1.0 cm long where it is electrically accelerated (Fig. 2-25). It emerges with velocity $v = 5.90 \times 10^6$ m/s. What was its acceleration, assumed constant? (Such a process occurs in the electron gun in a cathode-ray tube, used in television receivers and oscilloscopes.)

[0.0952381] ______ m/s^2



$$a_0 = \frac{v(t)^2 - v_0^2}{2(x(t) - x_0)} = \frac{(5.9\times 10^6)^2 - (1.3\times 10^5)^2}{2\cdot 0.01}\,\frac{(\text{m/s})^2}{\text{m}}$$

$$= 1.7\times 10^{15}\ \text{m/s}^2$$

Figure 2-25

$$v(t) = v_0 + a_0\, t$$
$$x(t) = x_0 + v_0\, t + ½\, a_0\, t^2 = x_0 + ½\,(v_0 + v(t))\, t$$
$$(v(t))^2 = (v_0)^2 + 2\, a_0\, (x(t) - x_0)$$

➔ $a_0 = -g = -9.8\ \mathrm{m/s^2}$

8. HRW6 2.P.054. [52229] A basketball player, standing near the basket to grab a rebound, jumps 90 cm vertically.

(a) How much (total) time does the player spend in the top 25 cm of this jump?

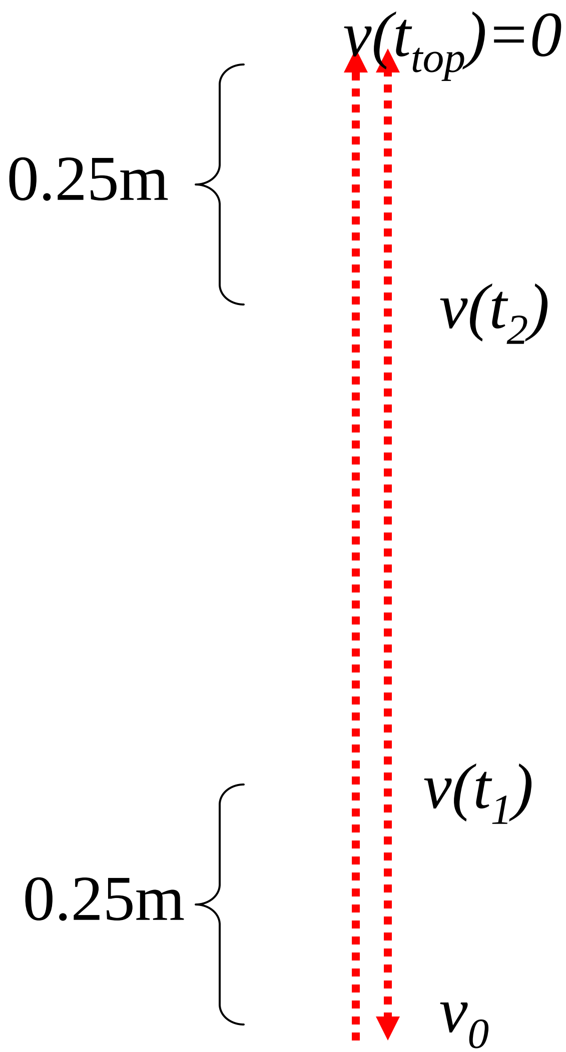
[0.0952381] ______ ms

(b) How much (total) time does the player spend in the bottom 25 cm of this jump?

[0.0952381] ______ ms

Does this help explain why such players seem to hang in the air at the tops of their jumps?

- No, it is an optical illusion and they spend the same amount of time at the tops and bottoms of their jumps.
- No, it is an optical illusion and they spend less time at the tops of their jumps.
- Yes, they spend more time at the tops of their jumps. [0.0952381]



$$v(t) = v_0 - g\,t$$
$$x(t) = x_0 + v_0\,t - ½\,g\,t^2$$
$$(v(t))^2 = (v_0)^2 - 2\,g(x(t) - x_0)$$

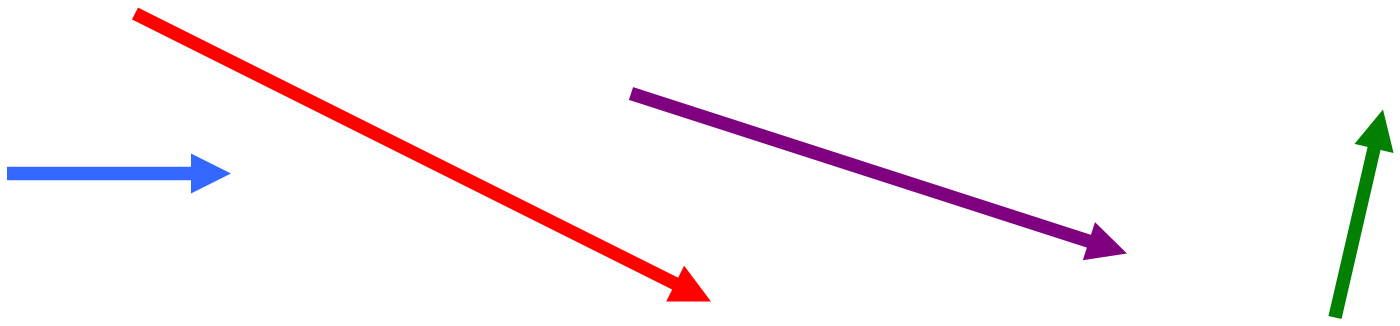
$$v(t_{top})^2 = v(t_2)^2 - 2g(x(t_{top}) - x(t_2))$$

$$v(t_2) = \pm\sqrt{2 \cdot 9.8 \cdot 0.25}\ \text{m/s} = \pm 2.2135\ \text{m/s}$$
$$= v(t_{top}) - 9.8(t_2 - t_{top})$$

$$(t_2 - t_{top}) = \frac{2.2135}{9.8}\text{s} = 0.2258\text{s}$$

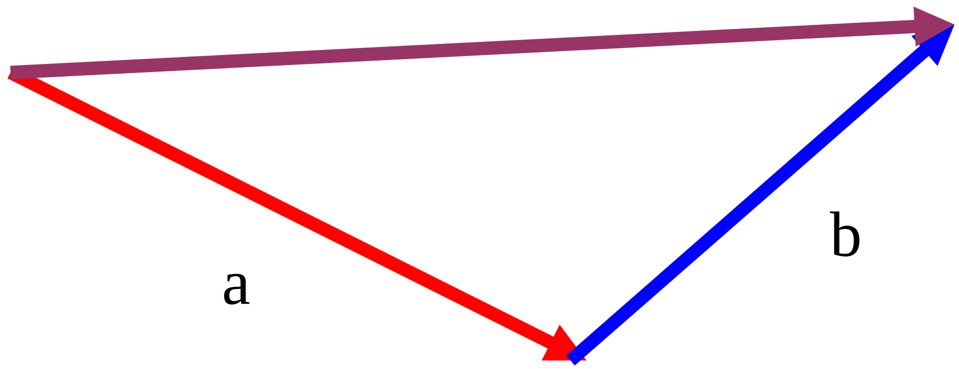
Definition of a vector

1. A vector can be visualized its length and direction.

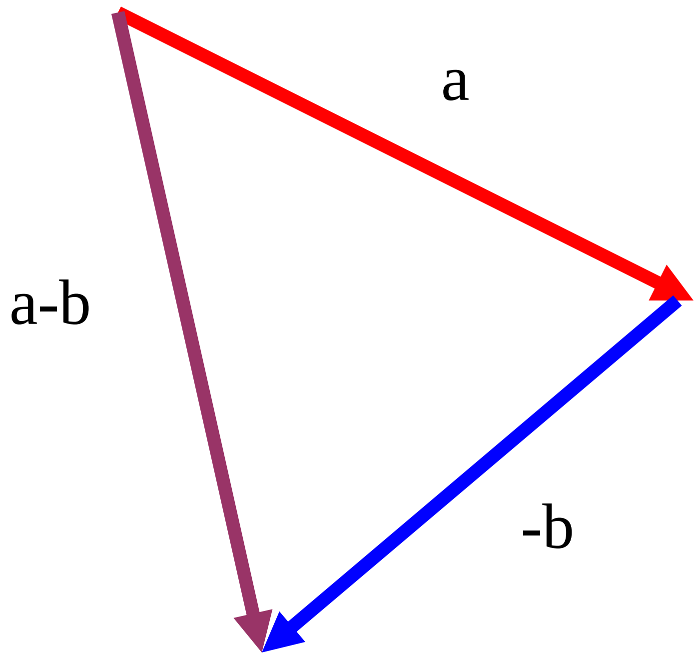


2. Addition, substraction, and two forms of multiplication can be defined
3. Coordinate representations, and abstract extensions.

Vector addition:

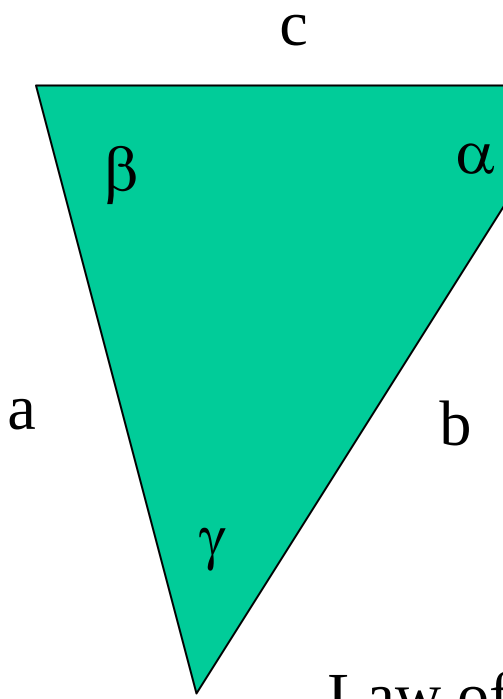


Vector subtraction:



Some useful trigonometric relations

(see Appendix E of your text)



Law of cosines:

$a^2=b^2+c^2-2bc\cos\alpha$

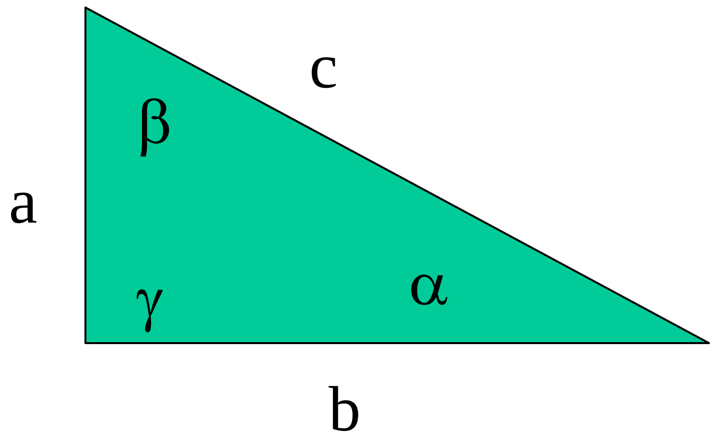
$b^2=c^2+a^2-2ca\cos\beta$

$c^2=a^2+b^2-2ab\cos\gamma$

Law of sines:

$$\frac{a}{\sin\alpha}=\frac{b}{\sin\beta}=\frac{c}{\sin\gamma}$$

Right triangle relations



$$c=\sqrt{a^2+b^2}$$

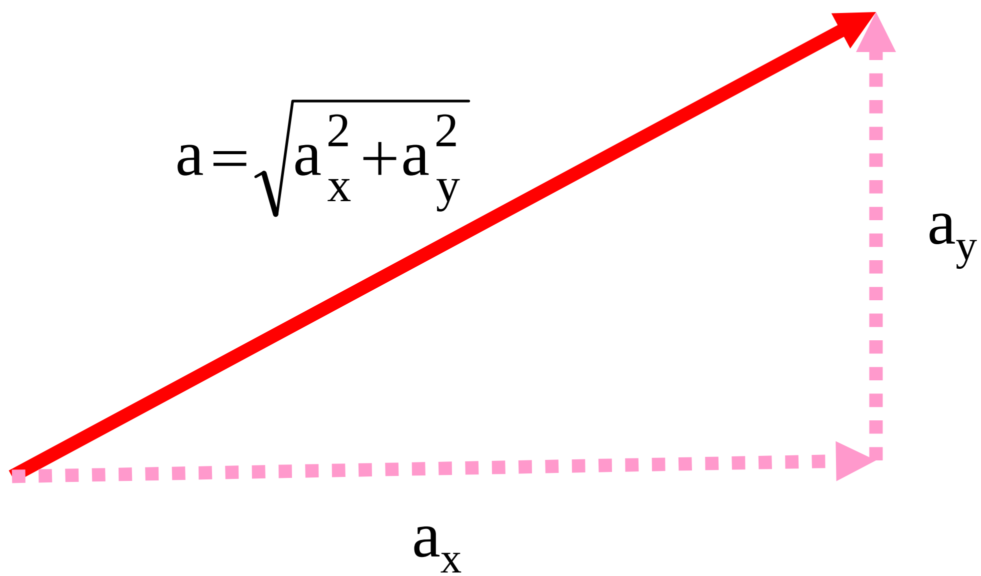
tan α = a/b

sin α = a/c

cos α = b/c

Vector components:

$$a = \sqrt{a_x^2 + a_y^2}$$



Vector components

$$\mathbf{R}_1 = x_1\hat{\mathbf{x}} + y_1\hat{\mathbf{y}} + z_1\hat{\mathbf{z}}$$

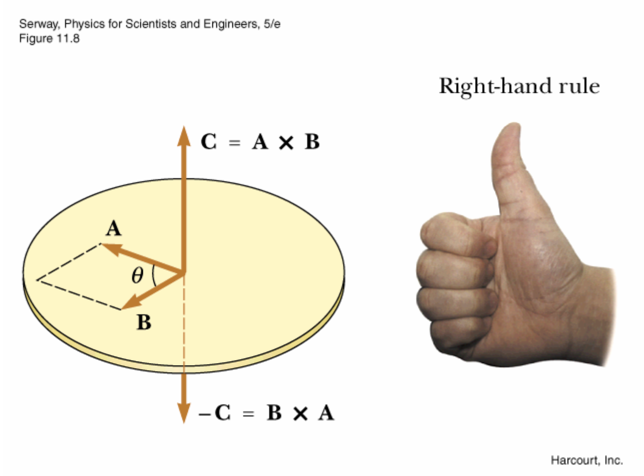
$$\mathbf{R}_2 = x_2\hat{\mathbf{x}} + y_2\hat{\mathbf{y}} + z_2\hat{\mathbf{z}}$$

$$\mathbf{R}_1 + \mathbf{R}_2 = (x_1 + x_2)\hat{\mathbf{x}} + (y_1 + y_2)\hat{\mathbf{y}} + (z_1 + z_2)\hat{\mathbf{z}}$$

Vector multiplication

"Dot" product $\mathbf{A} \bullet \mathbf{B} \equiv AB\cos\theta_{\mathrm{AB}};$ $\hat{\mathbf{x}} \bullet \hat{\mathbf{x}} = 1$

"Cross" product $|\mathbf{A} \times \mathbf{B}| \equiv AB\sin\theta_{\mathrm{AB}};$ $\hat{\mathbf{x}} \times \hat{\mathbf{y}} = \hat{\mathbf{z}}$



Examples of vectors: Position & Velocity

Serway, Physics for Scientists and Engineers, 5/e
Figure 4.1

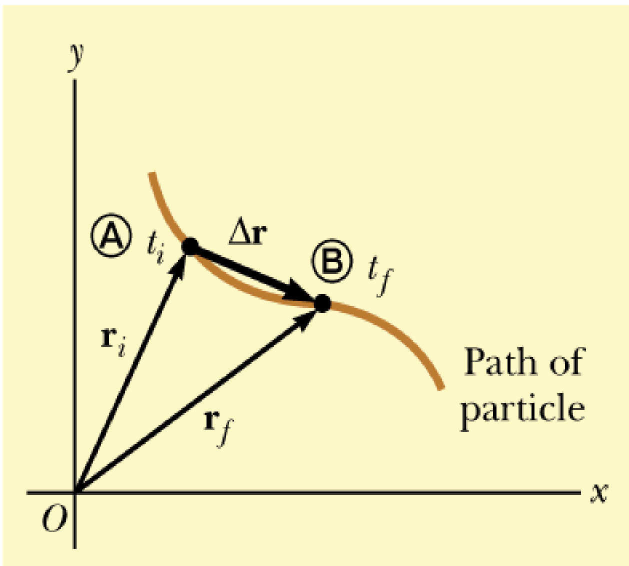


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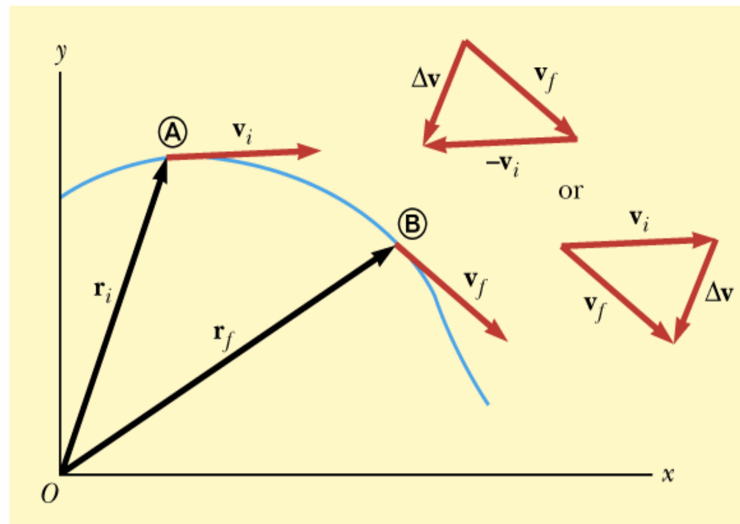
Figure 4.3



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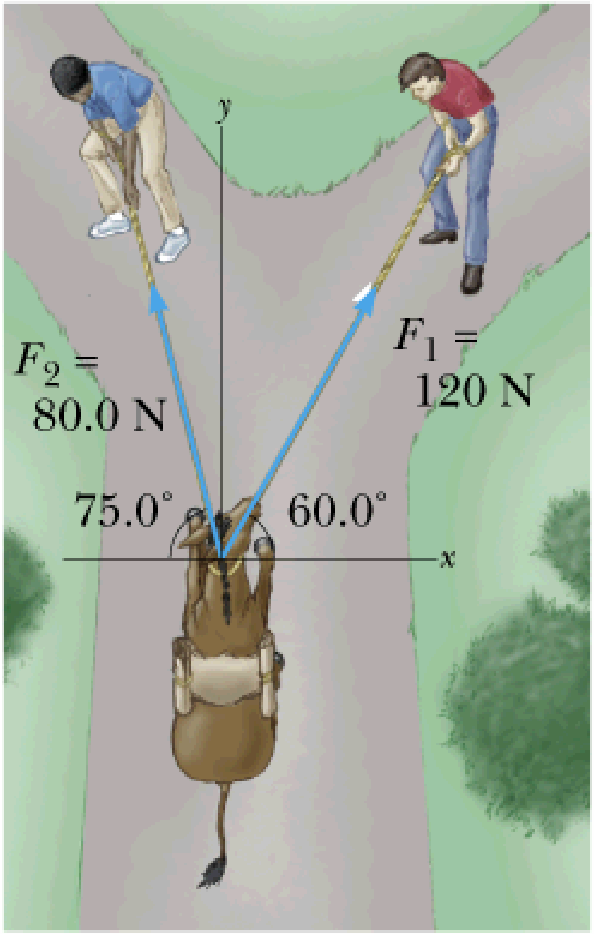
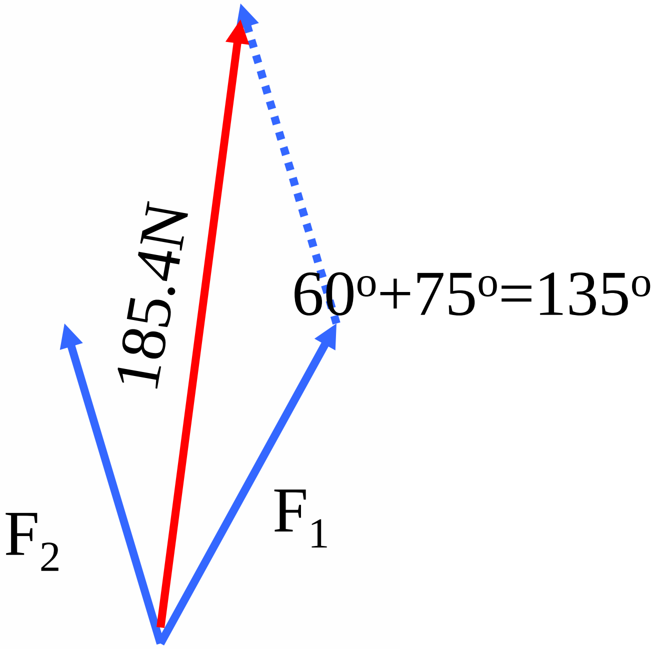
Problem 3.37





$$c^2 = a^2 + b^2 - 2ab\cos\gamma$$

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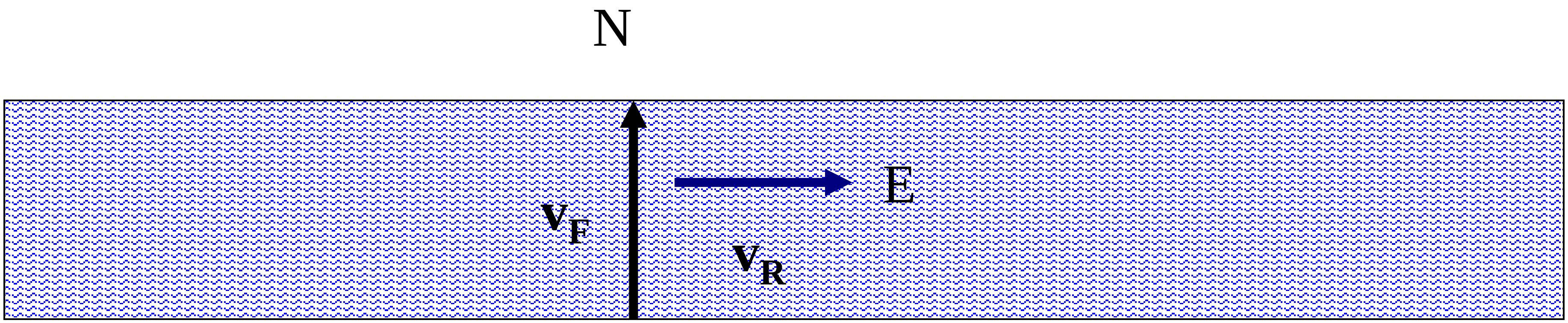
Peer instruction question



Suppose a Ferry moves due *north* at $\mathbf{v}_F$=4m/s across a river which is flowing *eas*t at a velocity of $\mathbf{v}_R$=3m/s. What is the velocity of the Ferry relative to the water?

(a)4m/s (north)   (b) 7m/s 37^O(east of north)

(c) 5m/s 37^O(east of north)   (d) 5m/s (west of north)