Week 4 Tutorial

Tutorial Section

Tutorial Time

Tutorial TA Name

Tutorial Structure

- Introduction
- Question 1
- Problem Solving Framework
- Question 2
- Problem Solving Framework
- Q&A

Question 1

3. An airplane flying at 800 km/h at 45° West of South relative to the air is subjected to a jet stream to the East of 170 km/h, relative to the ground.

(a) Draw a vector diagram showing how to graphically find $\vec{v}_{pg}$, the velocity of the plane relative to the ground as a vector sum of the two given vectors. On your diagram also label $\vec{v}_{pa}$: the velocity of the plane relative to the air; and $\vec{v}_{ag}$: the velocity of the air relative to the ground. /3

(b) Define an xy coordinate system with x pointing to the East and y pointing to the North. Solve for $(v_{pa})_x$, the x-component of the plane relative to the air. /3

(c) Solve for $(v_{pa})_y$, the y-component of the plane relative to the air. /3

(d) After writing $(v_{ag})_x$, use vector addition in component form to find $(v_{pg})_x$ and $(v_{pg})_y$. /4

(e) From your answers in part (d), solve for the speed of the airplane relative to the ground, v_{pg}. /2

(f) Solve for the angle West of South of the airplane relative to the ground. /3

Problem Solving Framework

PHYSICAL REVIEW PHYSICS EDUCATION RESEARCH **16,** 010123 (2020)

Template for teaching and assessment of problem solving in introductory physics

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1. Framing

Visual Representation

Assumptions and Simplifications

Relevant Concepts

Information Needed

Similar Problems

2. Planning

Solution Plan

Rough Estimate

3. Execution

Carry-out Plan for solving
- Work in algebra/symbols until the BITTER end
- Plug in numbers at the LAST step

4. Answer Checking

Compare to Estimate

Units Check

Limits Test

Getting (UnStuck)

Reference: Template for teaching and assessment of problem solving in introductory physics

1. Framing

2. Planning

3. Execution

4. Answer Checking

1. Framing

- Visual representation: Sketch the velocity vectors using cartesian coordinates.
- Assumptions and simplifications: This motion is restricted to 2D. Air resistance is negligible.
- Relevant concept: Vector operations, trigonometry.
- Information needed: Magnitudes and directions of the vectors.
- Similar problems: Vector addition problems, free body diagram problems.

2. Planning

- Rough estimate: By visualizing the vectors you can get a rough estimate of the magnitudes and directions of the resulting vector. In this example the plane is travelling at 45 degrees west of south at 800km/hr, and the wind is blowing to the east at 170km/hr, so the resulting vector will point in the southern direction and should have a magnitude of 600-700km/hr

- Solution plan: First define coordinate system. Draw vectors in coordinate system. Use vector addition and trigonometry to solve for all required variables.

3. Execution

- See solution on slide 11. Carry out the calculation, plug in the numbers at the last step.

4. Answer Checking

Compare to estimates: compare the calculation results to your rough estimates see whether the direction and magnitude of the resulting vector is close to what you estimated.

Units: The units should be consistent with the units for the quantities we were given.

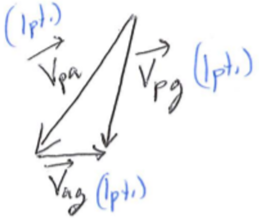
Limits: Not applicable here.

Getting (UnStuck)?

Solution

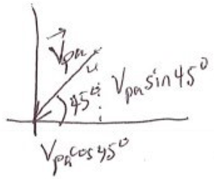
3. An airplane flying at 800 km/h at 45° West of South relative to the air is subjected to a jet stream to the East of 170 km/h, relative to the ground.

(a) Draw a vector diagram showing how to graphically find $\vec{v}_{pg}$, the velocity of the plane relative to the ground as a vector sum of the two given vectors. On your diagram also label $\vec{v}_{pa}$: the velocity of the plane relative to the air; and $\vec{v}_{ag}$: the velocity of the air relative to the ground. /3



$$\vec{V}_{pg} = \vec{V}_{pa} + \vec{V}_{ag}$$

(b) Define an xy coordinate system with x pointing to the East and y pointing to the North. Solve for $(v_{pa})_x$, the x-component of the plane relative to the air. /3



$$(V_{pa})_x = -V_{pa}\cos 45° = -\frac{800\,km/h}{\sqrt{2}} = -566\,\frac{km}{h}$$

(1pt.) sign (1pt.) (1pt.)

(c) Solve for $(v_{pa})_y$, the y-component of the plane relative to the air. /3

$$(V_{pa})_y = -V_{pa}\sin 45° = -566\,\frac{km}{h}$$

(1pt.) (1pt.) (1pt.)

(d) After writing $(v_{ag})_x$, use vector addition in component form to find $(v_{pg})_x$ and $(v_{pg})_y$. /4

$$(V_{ag})_x = 170\,\frac{km}{h} \quad \text{(1pt.)}$$

$$(V_{pg})_x = (V_{pa})_x + (V_{ag})_x = -566\,\frac{km}{h} + 170\,\frac{km}{h} = -396\,\frac{km}{h}$$

(1pt.) (1pt.)

$$(V_{pg})_y = -566\,\frac{km}{h} \quad \text{(1pt.)}$$

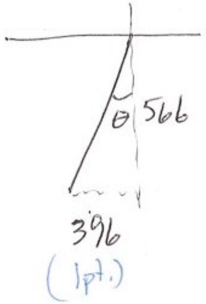
(e) From your answers in part (d), solve for the speed of the airplane relative to the ground, v_{pg}. /2

$$V_{pg} = \sqrt{(V_{pg})_x^2 + (V_{pg})_y^2} = \sqrt{(396)^2 + (566)^2}$$

(1pt.)

$$= 691\,\frac{km}{h} \quad \text{(1pt.)}$$

(f) Solve for the angle West of South of the airplane relative to the ground. /3



$$\tan\theta = \frac{396}{566} \quad \text{(1pt.)}$$

$$\theta = \tan^{-1}\left(\frac{396}{566}\right) = 35° \quad \text{(1pt.)}$$

so the airplane moves at $691\,\frac{km}{h}$, 35° West of South.

Question 2

1. In the children's book *Nuts to You*, a young squirrel named Jed is snatched up by a hawk. While in the air Jed manages to go limp, slip through the hawk's talons and fall to the forest floor. The hawk travels horizontally at a speed of 5 m/s. (You may neglect any effects of air resistance as you answer the following questions).

(a) Draw motion diagrams for both the hawk and Jed. Use circles for the hawk and squares for Jed and label a legend. Start your diagrams from the second before Jed is released and put a dot every second for 6 seconds. /7

(b) One second after being released, what is the x-component of Jed's velocity? Explain your answer. /2

(c) One second after being released, what is the y-component of Jed's velocity? Explain your answer. /2

(d) Does Jed or the hawk travel at a higher speed after Jed is released? Explain your answer. /2

(e) If Jed is released from a 20 m height, how long does it take him to hit the forest floor? Explain your answer. /3

(f) How far has Jed travelled horizontally as he fell? Explain your answer. /2

1. Framing

2. Planning

3. Execution

4. Answer Checking

1. Framing

- Visual representation: Jed will travel the same distance in the x-direction as the hawk, but the vertical distance between the hawk and Jed will get larger and larger after each time segment.
- Assumptions and simplifications: This motion is restricted to 2D. Air resistance is negligible.
- Relevant concept: Projectile motion
- Information needed: Initial velocity in x-direction of hawk and Jed. Height from ground.
- Similar problems: Projectile motion problems.

2. Planning

- Rough estimate: We can see for part b) that the x-direction velocity will remain constant. For part c), after 1 second the y-direction of the velocity should be around -10m/s because acceleration is roughly -10m/s^2.
- Solution plan: Use projectile motion equations along with relevant information to solve.

3. Execution

- See solution on slide 18. Carry out the calculation, plug in the numbers at the last step.

4. Answer Checking

Compare to estimates: compare the calculation results to your rough estimates see whether the sign matches and that your final result is close to your estimate.

Units: Units should be for velocities and distances, so m/s and m, respectively.

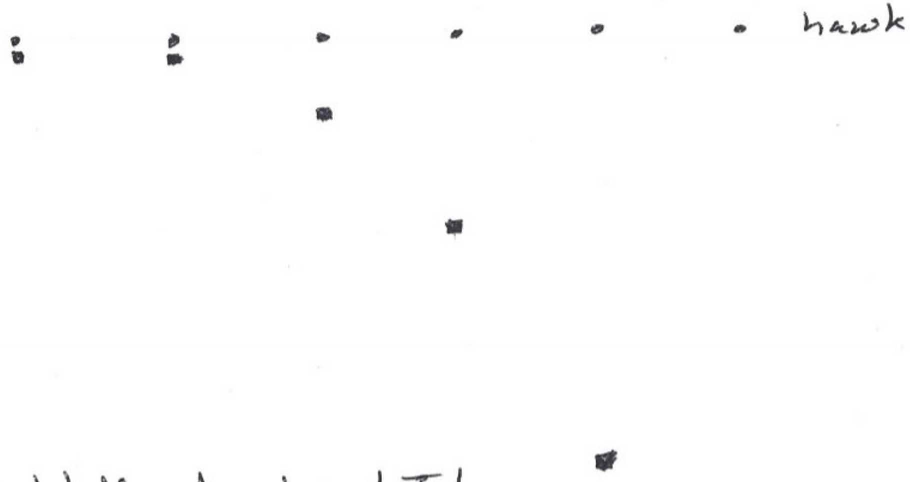
Limits:

Getting (UnStuck)?

Solution

1. In the children's book *Nuts to You*, a young squirrel named Jed is snatched up by a hawk. While in the air Jed manages to go limp, slip through the hawk's talons and fall to the forest floor. The hawk travels horizontally at a speed of 5 m/s. (You may neglect any effects of air resistance as you answer the following questions).

(a) Draw motion diagrams for both the hawk and Jed. Use circles for the hawk and squares for Jed and label a legend. Start your diagrams from the second before Jed is released and put a dot every second for 6 seconds. /7



1pt. labeling hawk and Jed.

$\frac{1}{2}$ pt. per dot: uniformly spaced for hawk

$\frac{1}{2}$ pt. per dot for Jed: directly below hawk with increasing vertical separation starting at third dot.

Jed

(b) One second after being released, what is the x-component of Jed's velocity? Explain your answer. /2

$V_{xJ} = 5\,m/s$ (1pt.) Jed maintains the x-component of his velocity. $(a_x = 0\,m/s^2)$ (1pt.)

(c) One second after being released, what is the y-component of Jed's velocity? Explain your answer. /2

$V_{yJf} = V_{yJi} - g\Delta t = -(9.8\,m/s^2)(1s) = -9.8\,m/s$ (1pt.) (1pt.)

(d) Does Jed or the hawk travel at a higher speed after Jed is released? Explain your answer. /2

Jed travels at a higher speed (1pt.) after release as he accelerates (non-zero V_y) downwards (1pt.) and maintains his horizontal speed. $V = \sqrt{V_x^2 + V_y^2}$

(e) If Jed is released from a 20 m height, how long does it take him to hit the forest floor? Explain your answer. /3

$\Delta y = -20m = -\frac{1}{2}g(\Delta t)^2 = -4.9\,\Delta t^2$ (1pt.) $\quad \Delta t^2 = \frac{20m}{4.9\,m/s^2}$ (1pt.)

$\Delta t = 2.0s$ (1pt.)

(f) How far has Jed travelled horizontally as he fell? Explain your answer. /2

$\Delta X = V_x \Delta t = (5\,m/s)(2.0s) = 10\,m$. (1pt.) (1pt.)