2. Bounce

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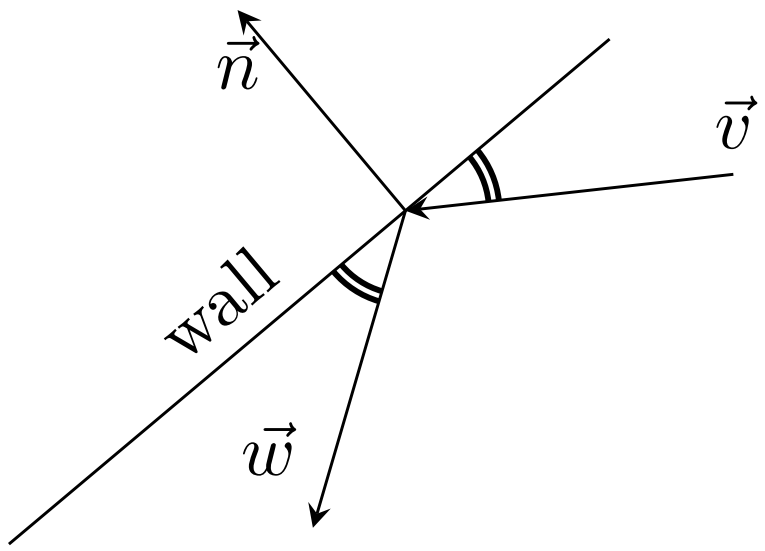
Problem Set B due Sep 15, 2021 20:30 IST

Practice

Setup

In Recitation 5, you practiced finding an outgoing velocity vector of a particle that bounces off a wall. In this problem, you will generalize this calculation and express the answer using matrices.

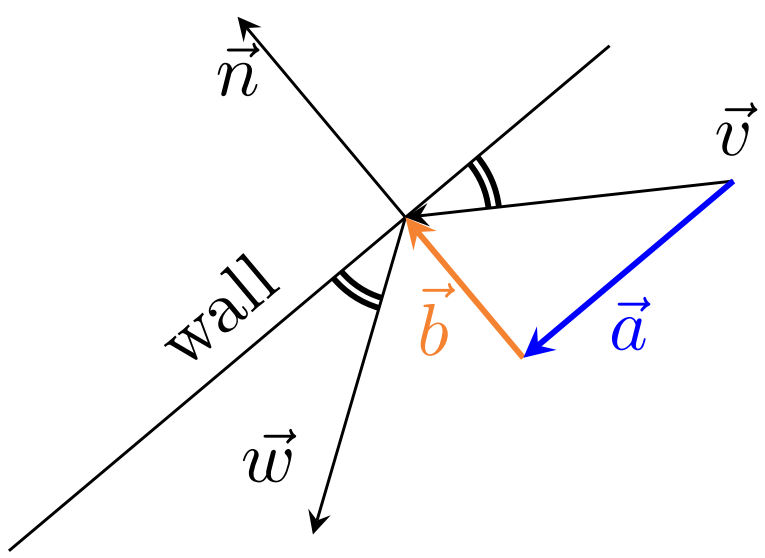
The following image depicts the setup:



In the picture, $\vec{v}$ is the velocity of the projectile before it hits the wall, and $\vec{w}$ is the velocity of the projectile after it hits the wall. The vector $\vec{n}$ is a normal vector to the wall. Assume $|\vec{n}| = 1$.

Physics tells us that the angle of incidence equals the angle of reflection – the two marked angles in the picture are equal. It also tells us that if there is no friction, then $|\vec{v}| = |\vec{w}|$. Given $\vec{v}$ and $\vec{n}$, our goal is to find $\vec{w}$.

We will break this big problem into several steps. We begin by breaking $\vec{v}$ into a piece parallel to $\vec{n}$ and a piece perpendicular to $\vec{n}$, as in the following picture.



Find w from a and b

1/1 point (graded)

Find a formula for $\vec{w}$ in terms of $\vec{a}$ and $\vec{b}$. Write `veca` and `vecb` for $\vec{a}$ and $\vec{b}$.

$\vec{w} =$ veca - vecb ✔ **Answer:** veca - vecb

Solution:

Bouncing off the wall reverses $\vec{b}$ and leaves $\vec{a}$ the same. Therefore, $\vec{w} = \vec{a} - \vec{b}$.

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Answers are displayed within the problem

Find length of b from v and n

1/1 point (graded)

What is the length of the vector $\vec{b}$? Enter a formula in terms of $\vec{v}$ and $\vec{n}$.

Write `vecv` for $\vec{v}$ and `vecn` for $\vec{n}$. You may write a dot product such as $\vec{u} \cdot \vec{w}$ using `vecu * vecw`.

$|\vec{b}| =$ vecv*vecn ✔ **Answer:** vecv*vecn

Solution:

By trigonometry we have $|\vec{b}| = |v| \cos\theta$, where θ is the angle between $\vec{v}$ and $\vec{b}$. Since $\vec{b}$ is parallel to $\vec{n}$, this θ is also the angle between $\vec{v}$ and $\vec{n}$. Since $|\vec{n}| = 1$, we have $\cos\theta = \frac{v \cdot n}{|\vec{v}|}$. Substituting this $\cos\theta$ in to the above formula for $|\vec{b}|$ we obtain $|\vec{b}| = \vec{v} \cdot \vec{n}$.

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Find a from v and n

1/1 point (graded)

Find a formula for $\vec{a}$ from $\vec{v}$ and $\vec{n}$.

Write `vecv` for $\vec{v}$ and `vecn` for $\vec{n}$. You may also write a dot product between two vectors using `*`. To write a scaled vector such as $2\vec{v}$, enter `2*vecv`.

$\vec{a} =$ vecv - (vecv*vecn)*vecn ✔ **Answer:** vecv-(vecv*vecn)*vecn

Solution:

Since $\vec{v} = \vec{a} + \vec{b}$, we have $\vec{a} = \vec{v} - \vec{b}$. Substituting the value for $\vec{b}$ found in the previous problem, we obtain $\vec{a} = \vec{v} - (v \cdot \vec{n})\,\vec{n}$.

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Find w from v and n

1/1 point (graded)

Find a formula for $\vec{w}$ from $\vec{v}$ and $\vec{n}$.

Write `vecv` for $\vec{v}$ and `vecn` for $\vec{n}$. You may also write a dot product between two vectors using `*`. To write a scaled vector such as $2\vec{v}$, enter `2*vecv`.

Calculator Hide Notes

$\vec{w} =$ vecv - 2*(vecv*vecn)*vecn ✔ **Answer:** vecv-2*(vecv*vecn)*vecn

Solution:

Since $\vec{w} = \vec{a} - \vec{b}$, and $\vec{v} = a + b$, we have $\vec{w} = \vec{v} - 2\vec{b}$. Substituting the value for $\vec{b}$ found in the previous problem, we obtain $\vec{w} = \vec{v} - 2\,(v \cdot \vec{n}) \cdot \vec{n}$.

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