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10. Robot arm with two joints

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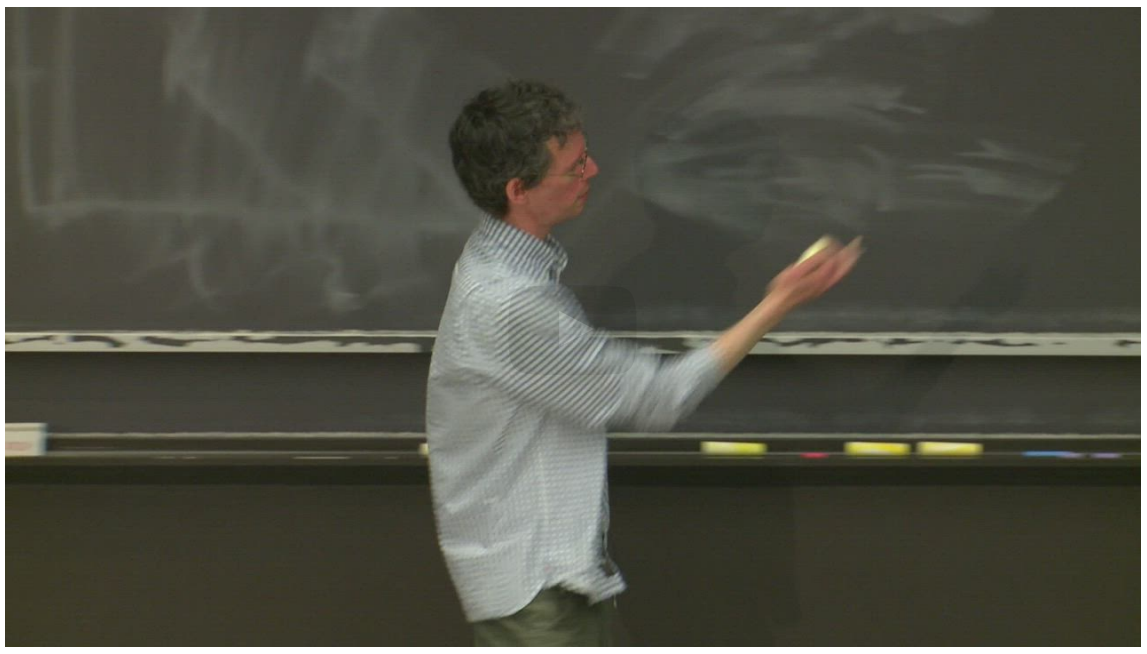
Application



0:00 / 0:00 2.0x

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PROFESSOR: So I remember learning this, what it means to add vectors when I was a student.

And I mean, it looks geometrically reasonable.

And the formula is kind of nice, but I thought, why

is this natural and important?

Why does this happen in a lot of places?

One place it happens is in physics

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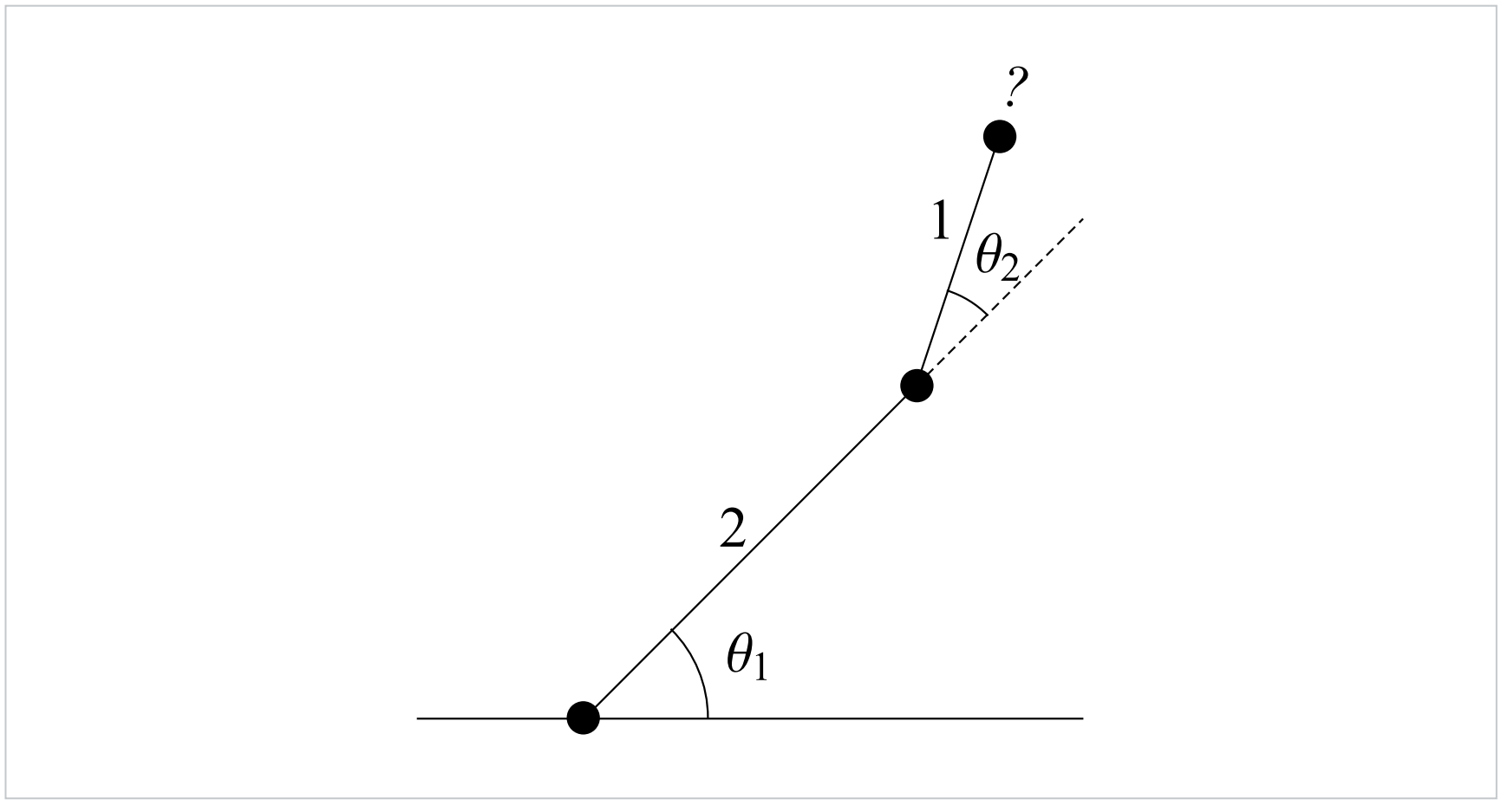
Robot arm with two joints

1/1 point (graded)
Consider the simple robot arm drawn below.



We want to find the position of the upper robot arm segment in terms of θ_1 and θ_2.

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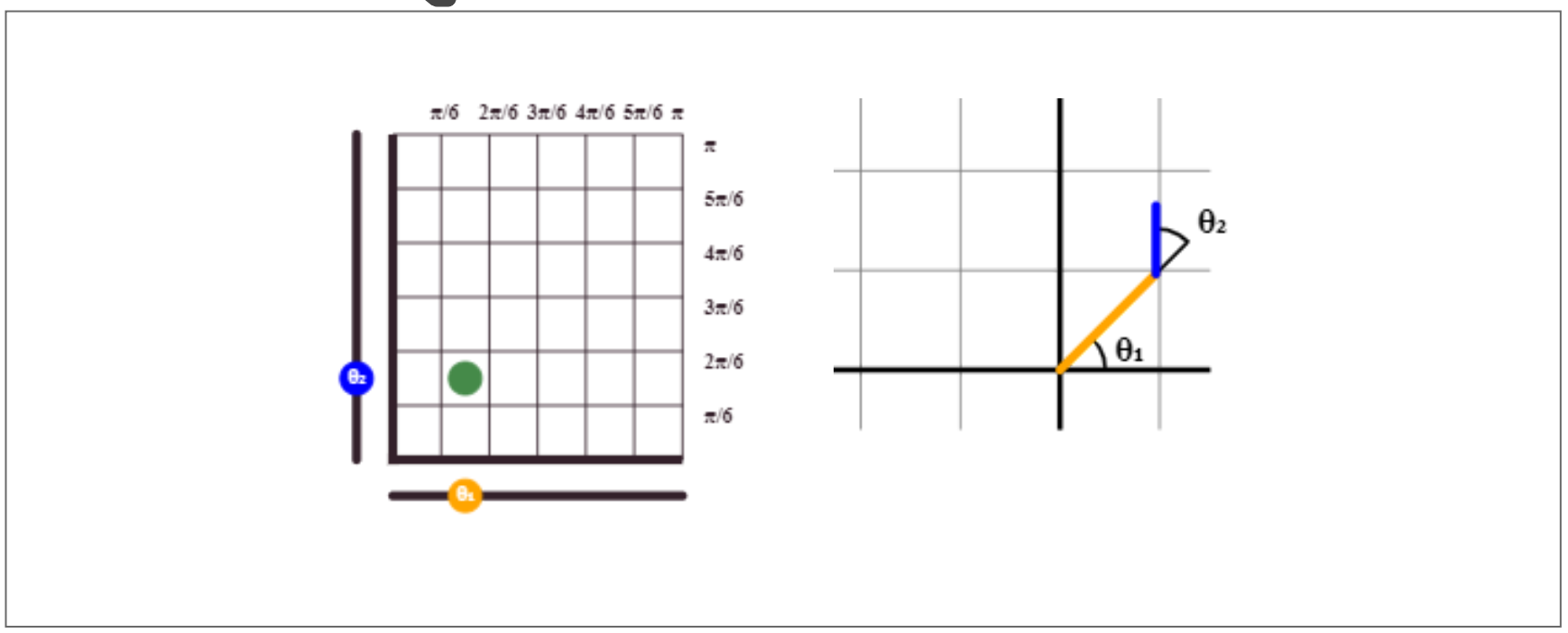
You can test out how this behaves by moving the $\boldsymbol{\theta_1}$ and $\boldsymbol{\theta_2}$ sliders in the applet below either independently, or by dragging the green dot directly. Watch as the position of the robot arm moves with respect to changes in theta input variables $\boldsymbol{\theta_1}$ and $\boldsymbol{\theta_2}$.

▶ Robot Arm Interactive



A hint to get started

That sounds pretty overwhelming. But let's try to relate this picture to things we've seen already. This picture kind of looks like our picture for vector addition

$$\vec{u} + \vec{w}.$$

We also have angles and lengths, which might remind us of the vector $\vec{v} = (3\cos\theta, 3\sin\theta)$. So we can describe the lower segment of the robot arm by

$$\vec{u} = \langle 2\cos(\theta_1), 2\sin(\theta_1)\rangle$$

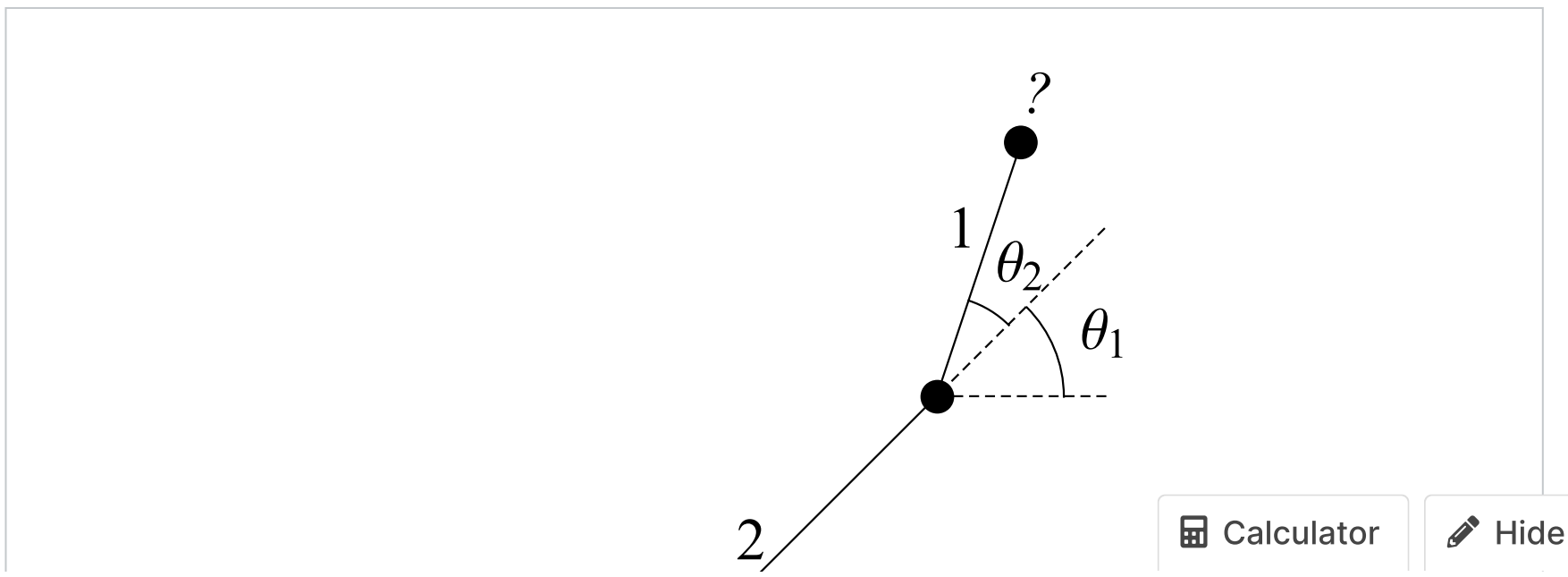
Find the vector $\vec{w}$.

- $\vec{w} = \langle \cos(\theta_2), \sin(\theta_2)\rangle$
- ✔ $\vec{w} = \langle \cos(\theta_1 + \theta_2), \sin(\theta_1 + \theta_2)\rangle$
- $\vec{w} = \langle \cos(\theta_1) + \cos(\theta_2), \sin(\theta_1) + \sin(\theta_2)\rangle$

✔

Solution:

The answer comes from the following figure:



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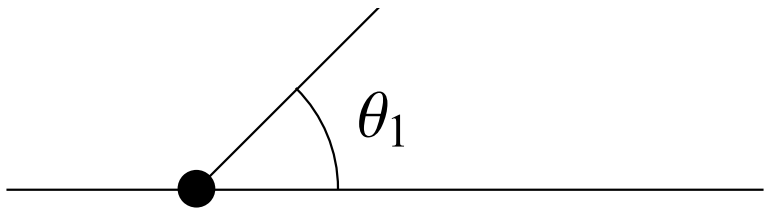


So we have

$$\langle \underbrace{x\left(\theta_1, \theta_2\right)}_{\text{fcn of angles}}, \underbrace{y\left(\theta_1, \theta_2\right)}_{\text{fcn of angles}} \rangle = \vec{u} + \vec{w} = \langle 2\cos\theta_1 + \cos\left(\theta_1 + \theta_2\right), 2\sin\theta_1 + \sin\left(\theta_1 + \theta_2\right) \rangle.$$

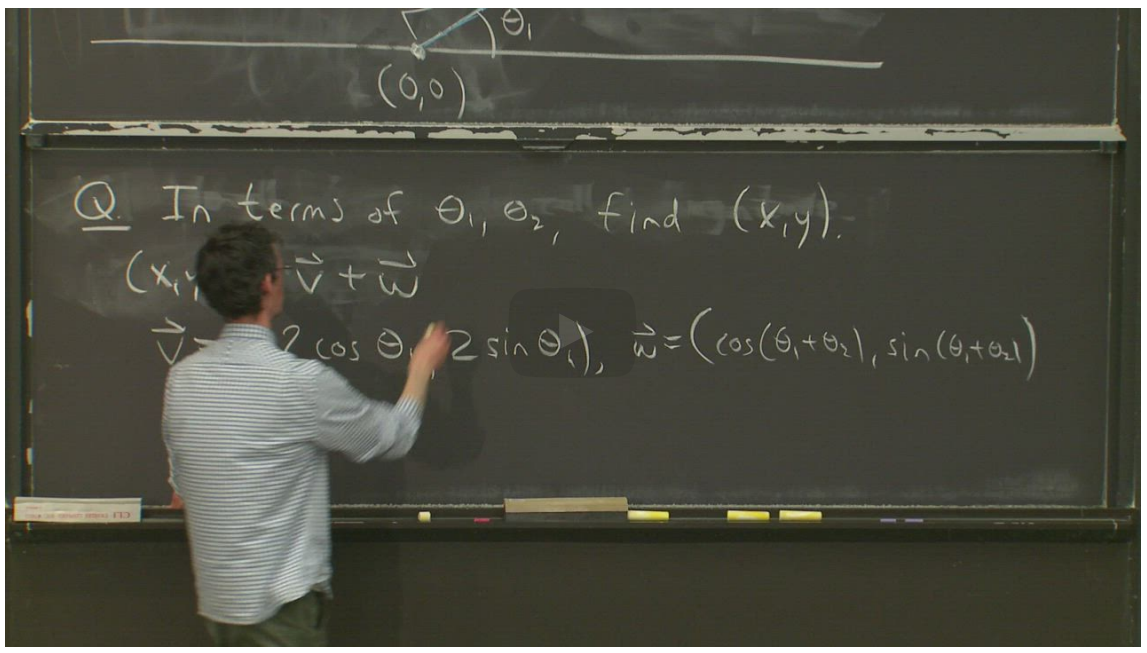
Submit You have used 1 of 3 attempts

Answers are displayed within the problem

Don't worry!

This looks pretty complicated, but later in the course we will develop some tools for analyzing something like this. We will leave this problem as it is for now and come back to it in future lectures.

Don't worry!



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PROFESSOR: And so then we can write a whole formula

for (x,y).

So now I want to add v and w.

So the first component is the sum

of the first components 2 cosine of theta 1

plus the cosine of theta 1 plus theta 2.

And then the second component is 2 sin of theta 1

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