You can draw here

Physics 111 - Class 13A
Angular Momentum

Do not draw in/on this box!

November 29, 2021

You can draw here

You can draw here

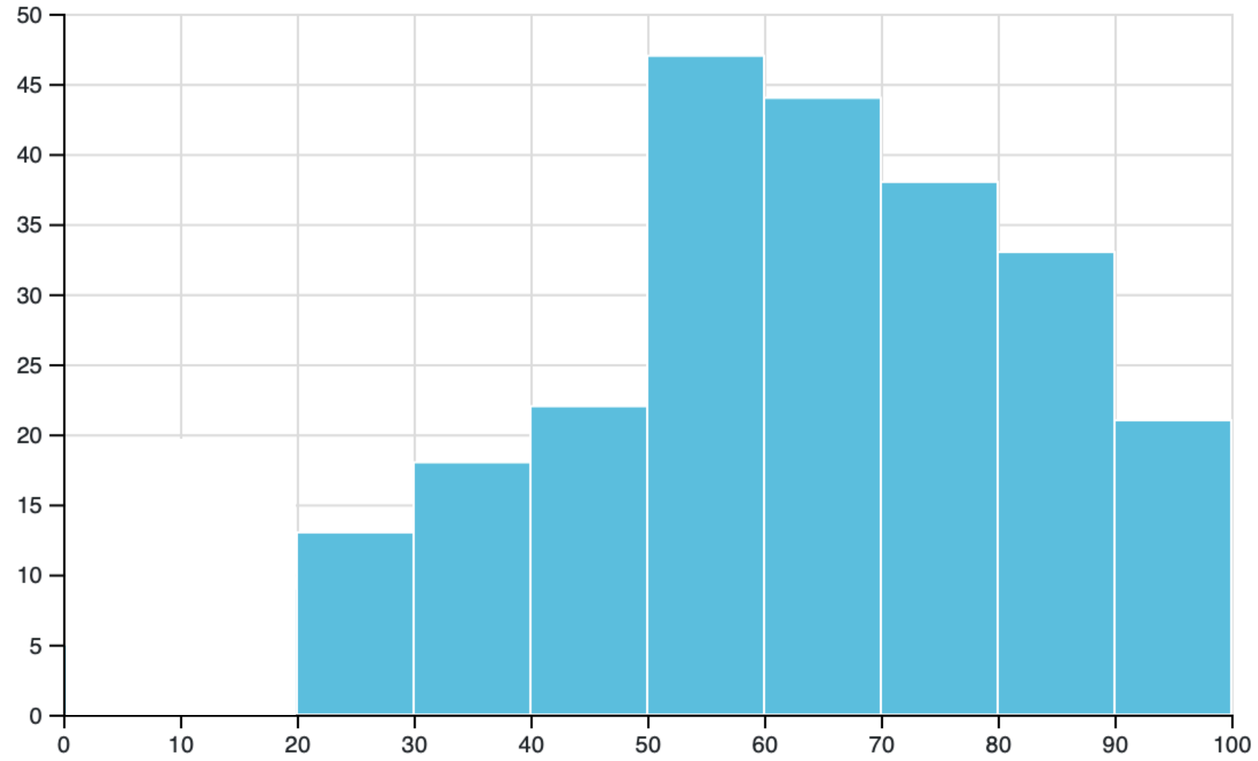
Class Outline

- Logistics / Announcements
- Test 5 Reflection
- Angular Momentum Summary
- Clicker Questions
- Worked Problems

Logistics/Announcements

- Labs are done!!
- HWs are done!!
- Last Learning Log 11 due on Saturday at 6 PM
- Test/Bonus Test: Bonus Test 5 available this week (Chapter 9)
  - Test Window: Friday 6 PM - Sunday 6 PM

Test 4 Reflection



Number of students	250
Mean score	61%

- Test 5 was right on the mark…
  - Time was not a factor
  - Several conceptual questions
- Will go over Question 9 together

Q9: Head-on Collision of Carts

A cart of relative mass $9m$ (Cart 1) moving with velocity $\vec{v_0} = (\ 19.5\ m/s)\hat{\imath}$ collides head-on with a cart of relative mass 6 m (Cart 2) that is initially at rest. Ignore friction.

Part 1

If the collision is perfectly inelastic, what is the final velocity of the two carts?

$v =$ number (rtol=0.05, atol=1e-08) $(m/s)\ \hat{\imath}$

Part 2

If the collision is elastic, what is the final velocity of Cart 1 (with mass 9 m).

$v_f =$ number (rtol=0.05, atol=1e-08) $(m/s)\ \hat{\imath}$

Part 3

If the collision is elastic, what is the final velocity of Cart 2 (with mass 6 m).

$v_f =$ number (rtol=0.05, atol=1e-08) $(m/s)\ \hat{\imath}$

Q9: Head-on Collision of Carts

A cart of relative mass $9m$ (Cart 1) moving with velocity $\vec{v}_0 = (\ 19.5\ m/s)\hat{\imath}$ collides head-on with a cart of relative mass 6 m (Cart 2) that is initially at rest. Ignore friction.

Part 1

If the collision is perfectly inelastic, what is the final velocity of the two carts?

$v =$ number (rtol=0.05, atol=1e-08) $(m/s)\ \hat{\imath}$

Part 2

If the collision is elastic, what is the final velocity of Cart 1 (with mass 9 m).

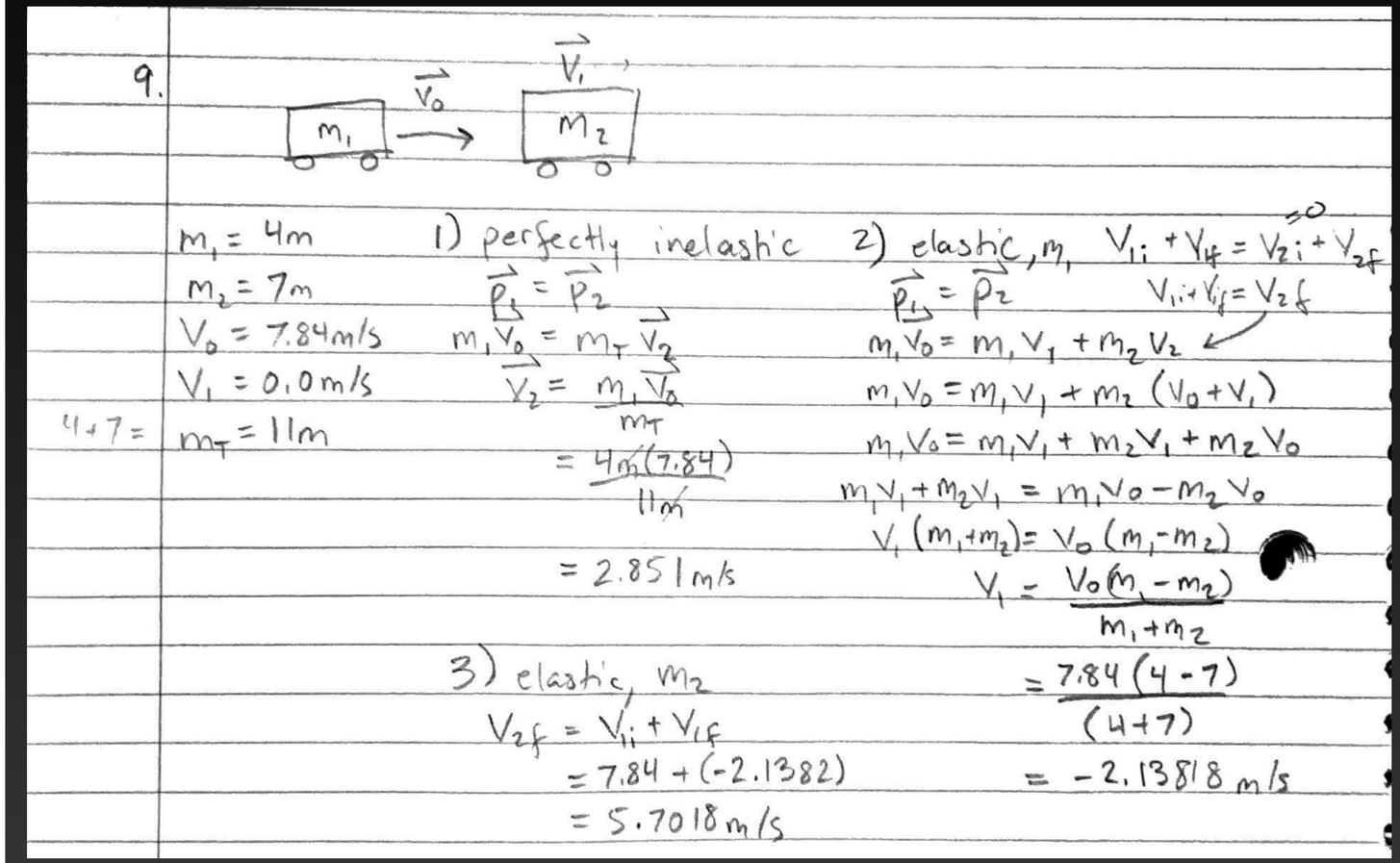
$v_f =$ number (rtol=0.05, atol=1e-08) $(m/s)\ \hat{\imath}$

Part 3

If the collision is elastic, what is the final velocity of Cart 2 (with mass 6 m).

$v_f =$ number (rtol=0.05, atol=1e-08) $(m/s)\ \hat{\imath}$

Sample Student Submission



Monday's Class

11.2 Angular Momentum
11.3 Conservation of Angular Momentum

Angular Momentum

- "Angular Momentum" is the rotational analogue of linear momentum
- An object rotates about an axis "carries" or "has" angular momentum

ANGULAR MOMENTUM OF A PARTICLE

The **angular momentum** $\vec{\mathbf{l}}$ of a particle is defined as the cross-product of $\vec{\mathbf{r}}$ and $\vec{\mathbf{p}}$, and is perpendicular to the plane containing $\vec{\mathbf{r}}$ and $\vec{\mathbf{p}}$:

$$\vec{\mathbf{l}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}. \qquad 11.5$$

- For a rigid body, rotating with angular velocity,

$$L = I\omega. \qquad 11.9$$

Angular Momentum

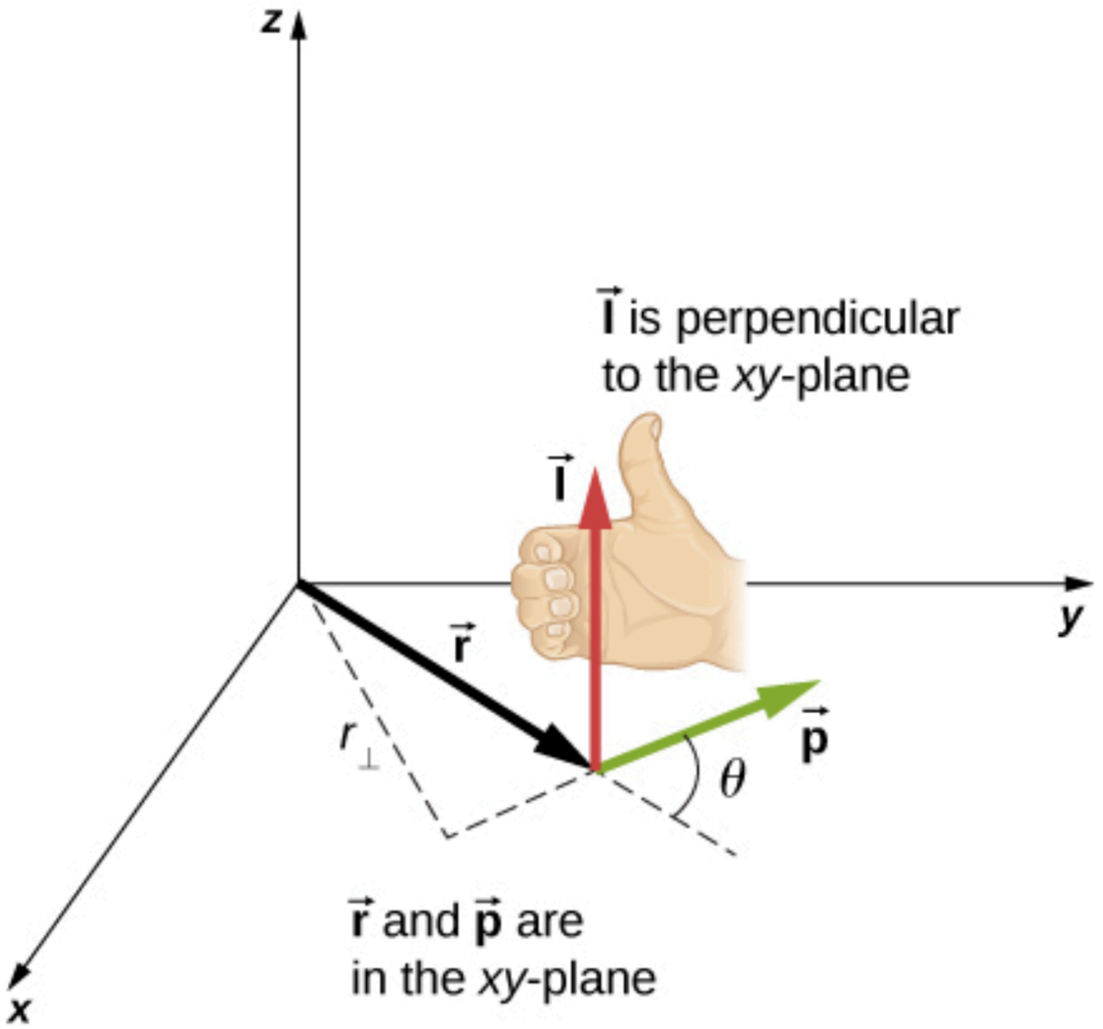


Figure 11.9 In three-dimensional space, the position vector $\vec{\mathbf{r}}$ locates a particle in the *xy*-plane with linear momentum $\vec{\mathbf{p}}$. The angular momentum with respect to the origin is $\vec{\mathbf{l}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$, which is in the *z*-direction. The direction of $\vec{\mathbf{l}}$ is given by the right-hand rule, as shown.

PROBLEM-SOLVING STRATEGY

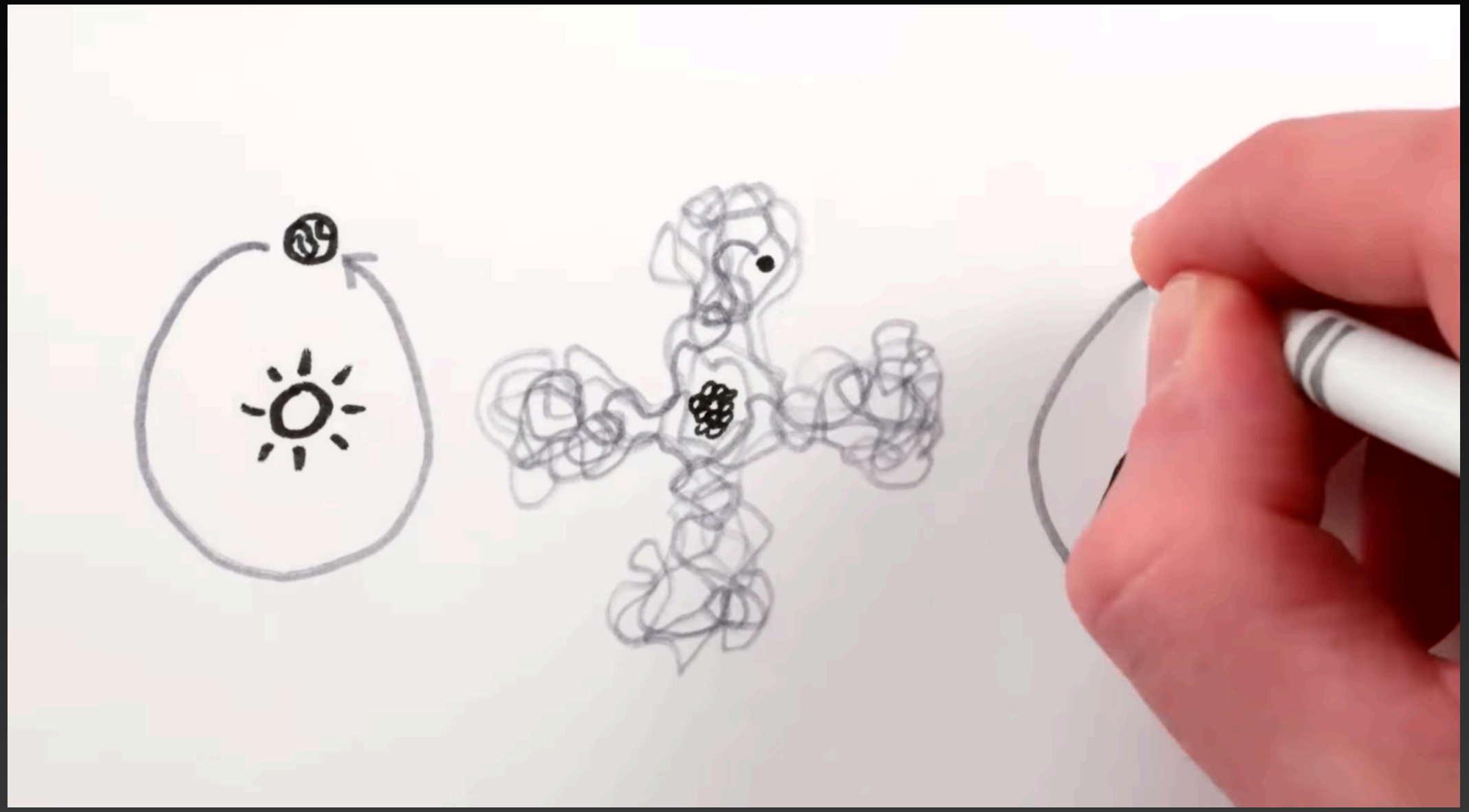
Angular Momentum of a Particle

1. Choose a coordinate system about which the angular momentum is to be calculated.
2. Write down the radius vector to the point particle in unit vector notation.
3. Write the linear momentum vector of the particle in unit vector notation.
4. Take the cross product $\vec{\mathbf{l}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$ and use the right-hand rule to establish the direction of the angular momentum vector.
5. See if there is a time dependence in the expression of the angular momentum vector. If there is, then a torque exists about the origin, and use $\frac{d\vec{\mathbf{l}}}{dt} = \sum \vec{\boldsymbol{\tau}}$ to calculate the torque. If there is no time dependence in the expression for the angular momentum, then the net torque is zero.

Properties of Angular Momentum

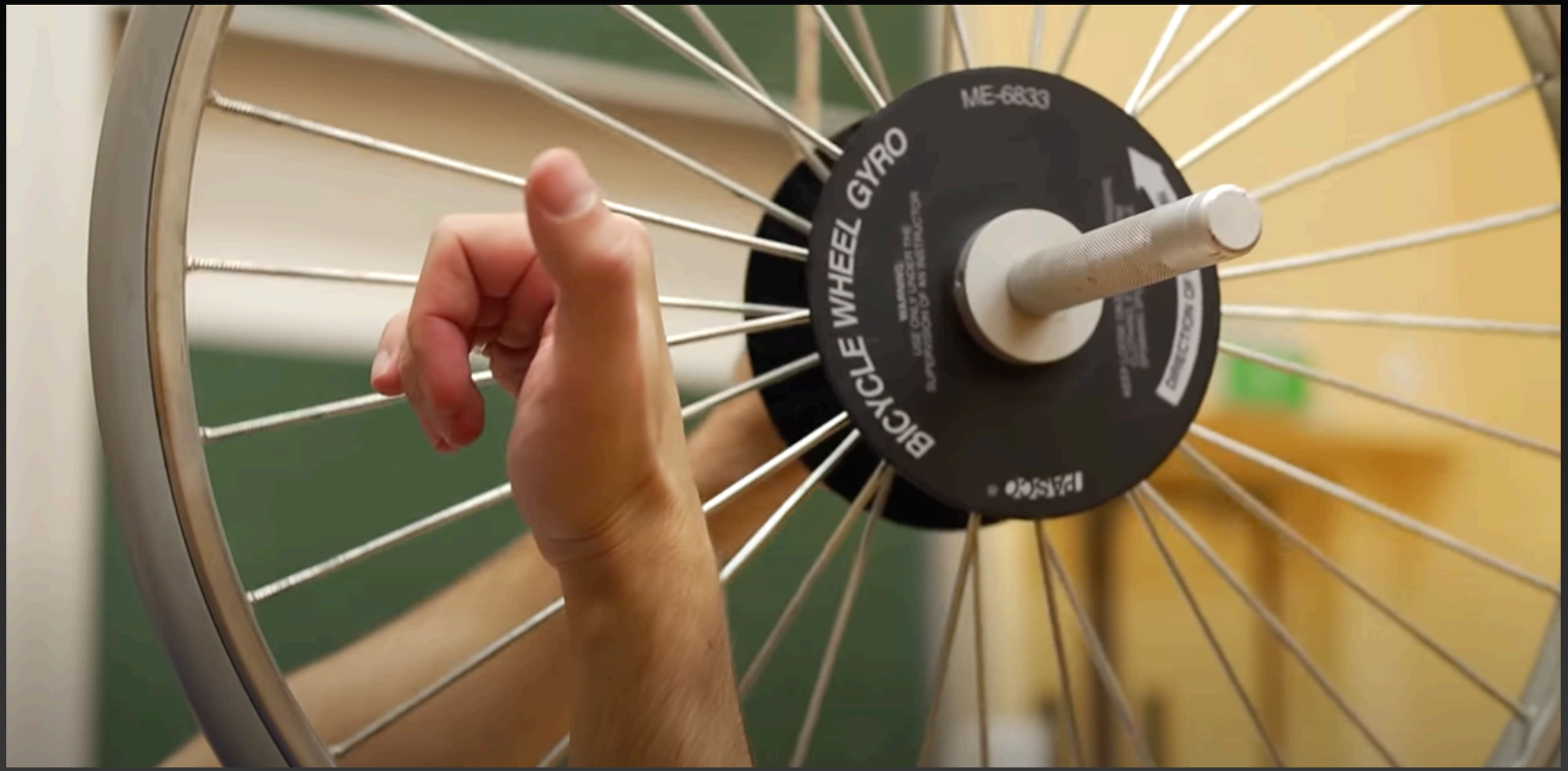
- Angular Momentum is a vector quantity, direction given by right hand rule
- The total angular momentum of a “system” is **conserved** if **there is no net torque on the system**

Angular Momentum



Link to Video

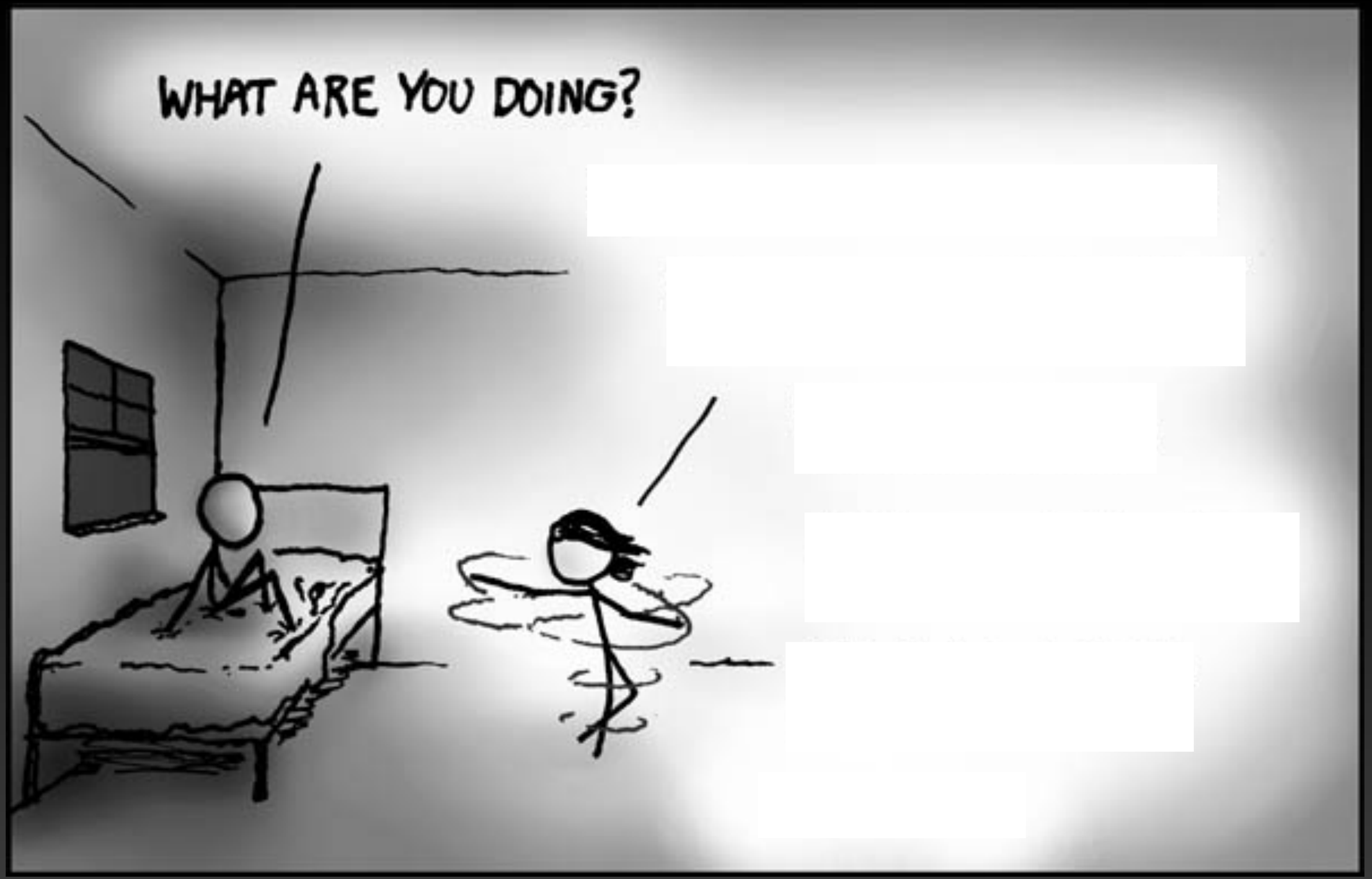
Gyroscopic Precession



Link to Video

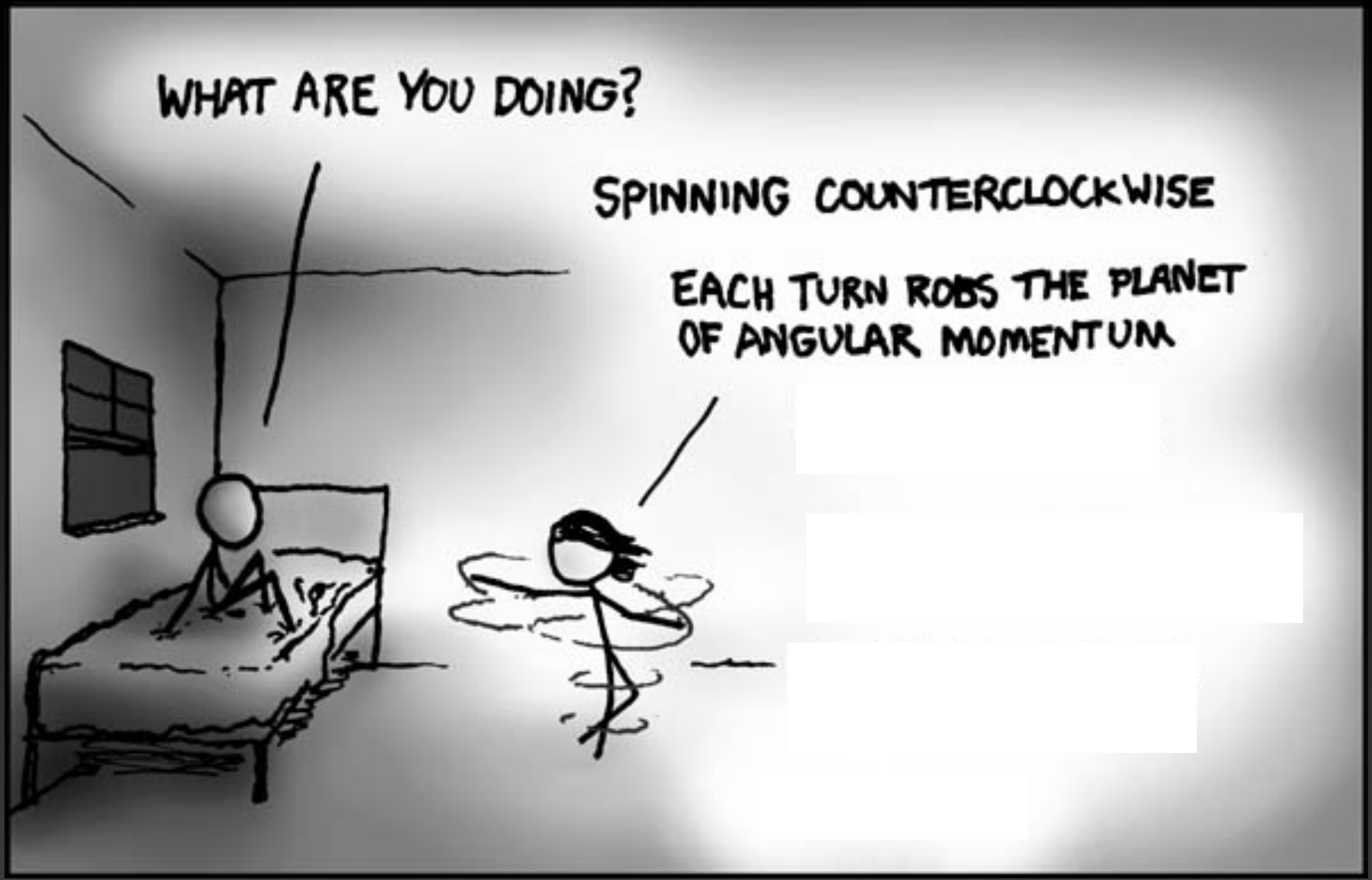
Angular Momentum Mystery?

Link to Video

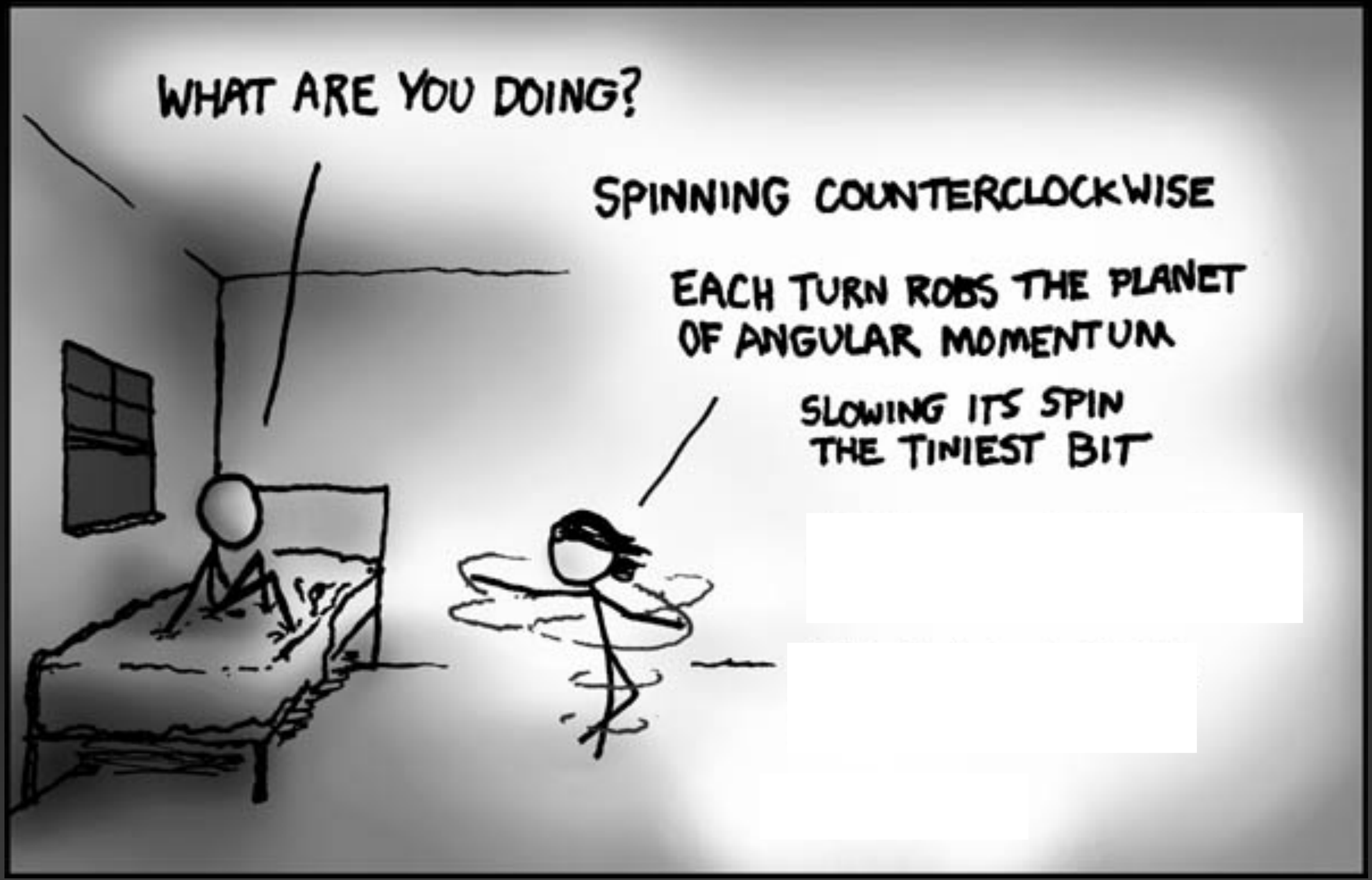


XKCD 162

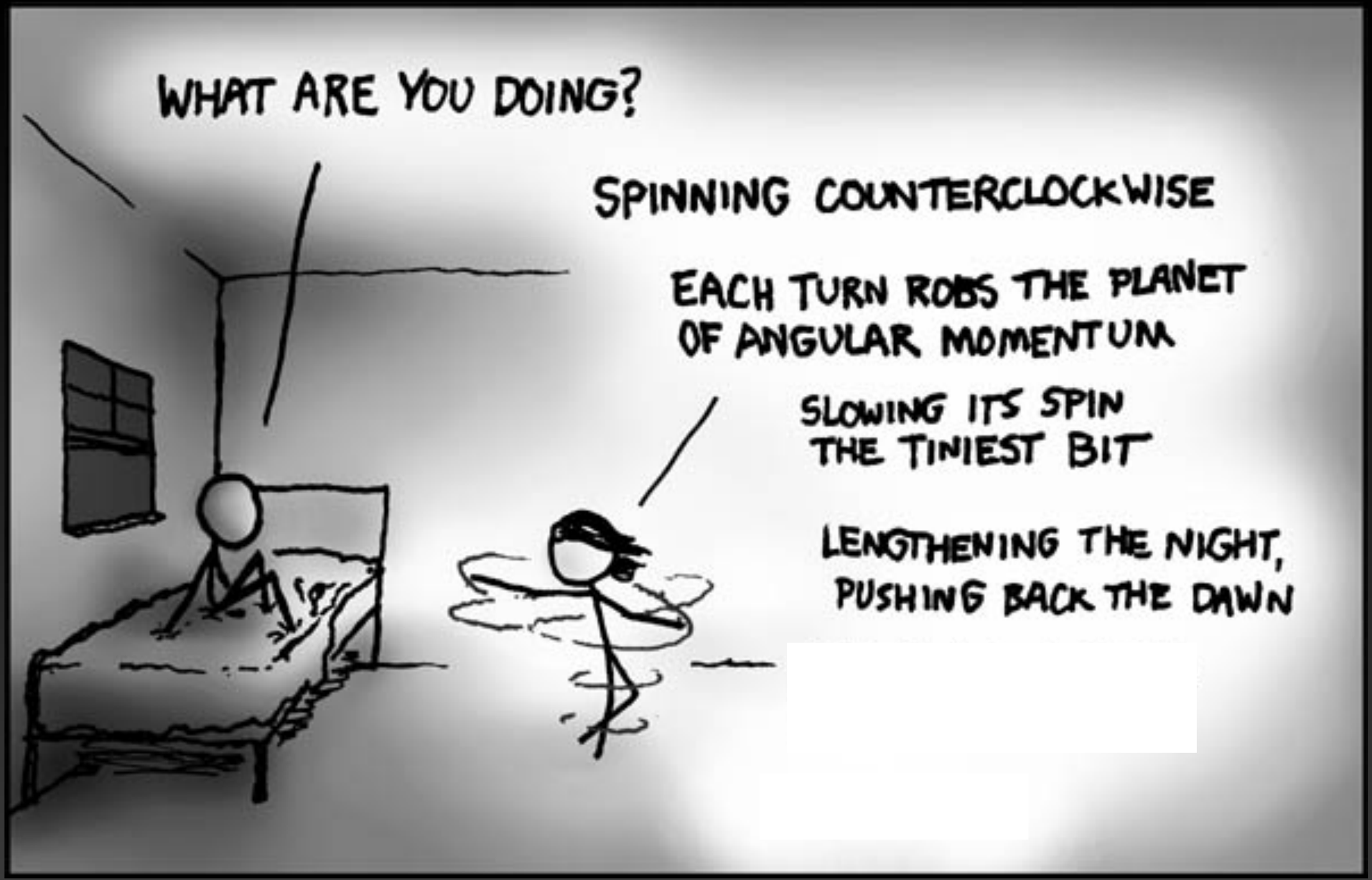
XKCD 162


WHAT ARE YOU DOING?
SPINNING COUNTERCLOCKWISE
EACH TURN ROBS THE PLANET OF ANGULAR MOMENTUM

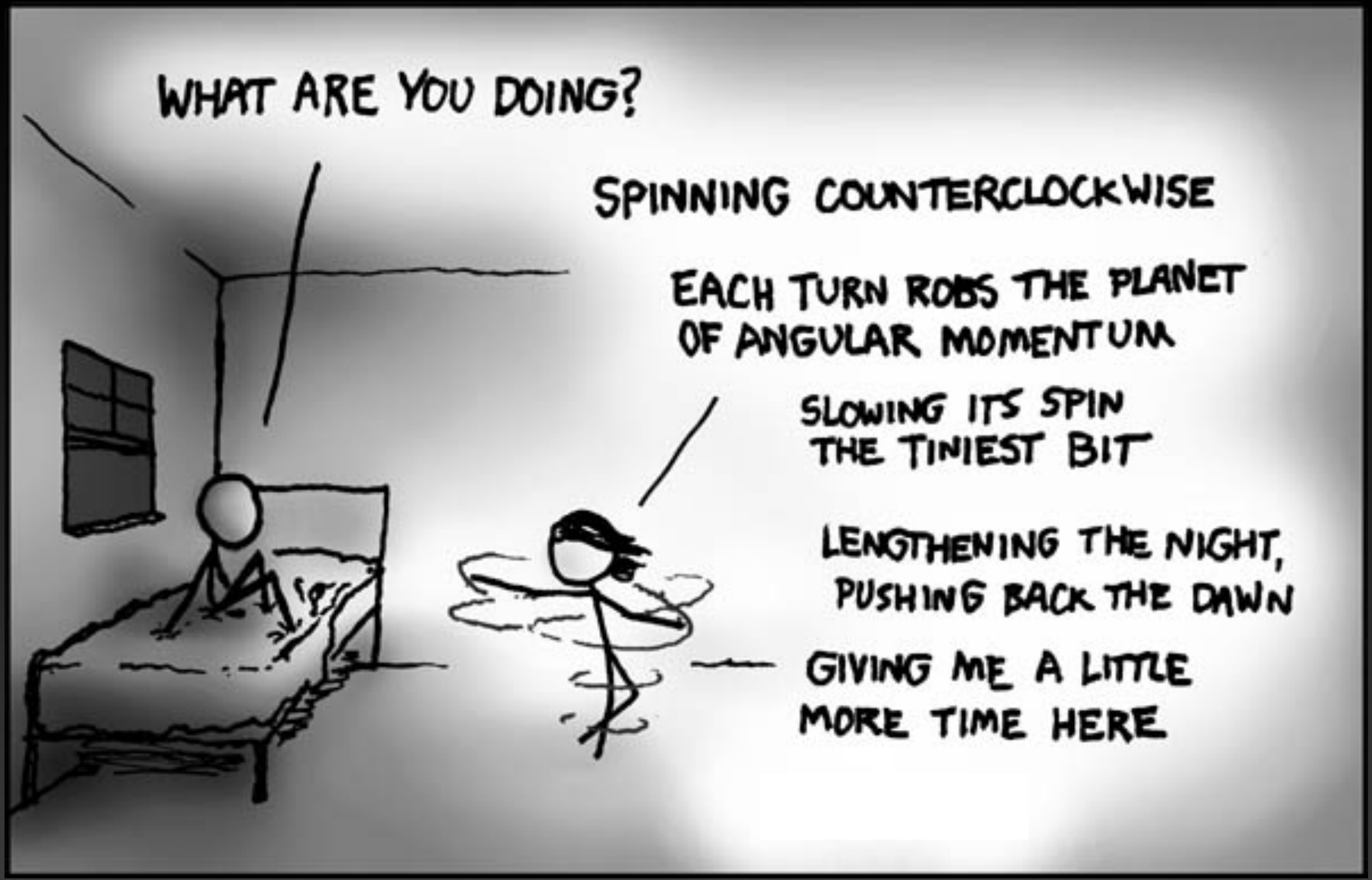
XKCD 162


WHAT ARE YOU DOING?
SPINNING COUNTERCLOCKWISE
EACH TURN ROBS THE PLANET OF ANGULAR MOMENTUM
SLOWING ITS SPIN THE TINIEST BIT

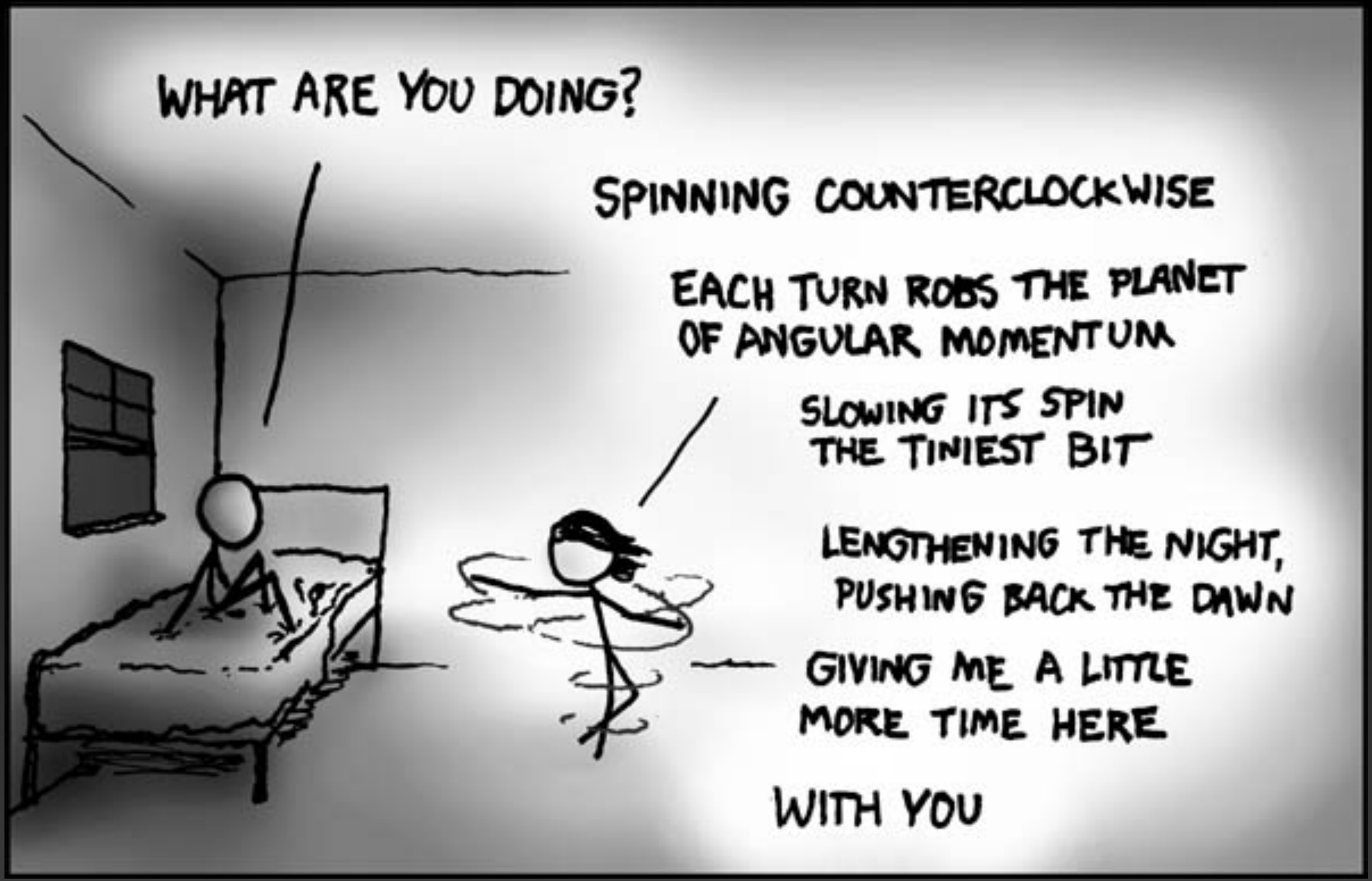
XKCD 162


WHAT ARE YOU DOING?
SPINNING COUNTERCLOCKWISE
EACH TURN ROBS THE PLANET OF ANGULAR MOMENTUM
SLOWING ITS SPIN THE TINIEST BIT
LENGTHENING THE NIGHT, PUSHING BACK THE DAWN

XKCD 162


WHAT ARE YOU DOING?
SPINNING COUNTERCLOCKWISE
EACH TURN ROBS THE PLANET OF ANGULAR MOMENTUM
SLOWING ITS SPIN THE TINIEST BIT
LENGTHENING THE NIGHT, PUSHING BACK THE DAWN
GIVING ME A LITTLE MORE TIME HERE

XKCD 162


WHAT ARE YOU DOING?
SPINNING COUNTERCLOCKWISE
EACH TURN ROBS THE PLANET OF ANGULAR MOMENTUM
SLOWING ITS SPIN THE TINIEST BIT
LENGTHENING THE NIGHT, PUSHING BACK THE DAWN
GIVING ME A LITTLE MORE TIME HERE
WITH YOU

XKCD 162

Reminder:
Everyone should try to come to Wednesday's class, we will discuss Final Exam logistics

See you next class!

Attribution

This resource was significantly adapted from the Open Stax Instructor Slides provided by Rice University. It is released under a CC-BY 4.0 license.

—— Original resource license ——