Physics 111 - Class 13A
Angular Momentum

November 28, 2022

Class Outline

- Logistics / Announcements
- Next few classes...
- Review Session
- Angular Momentum Summary

Logistics/Announcements

- Labs are done!!
- Tutorials are done !!
- HW 11 is the last HW (Randomized set of Review questions) !!
- Last Learning Log 11 due on Saturday at 6 PM
- Test 5 is this Friday (Chapters 9 and 10)
  - Bonus Test 5 will be...

LL 11

- Learning Log 11 will be available at the end of this week
  - We will take the 10 best Learning Logs
- Final chance to reflect on the course!
  - You should do it :-)

HW 11

- Homework 11 is an OPTIONAL assignment
- It contains a random set of 20 questions from HW2 - HW10
- We will take your 9 best scores between HW1 - HW11
- Remember, you cannot get over 100% on the homework portion of the course, and extra marks do not transfer anywhere

HW 11

*(Note: for full disclosure, I am **definitely** tricking you into doing more physics problems for extra marks so you can be more prepared for the final so you can get a better mark!)*

This is OPTIONAL! If you have other courses you're struggling more in, obviously spend this time there rather than trying to get an extra few marks on HW.

The last few classes…

Class Session	What we're doing
Today (Monday Nov. 28th)	Angular Momentum (not tested on Test 5)
Wednesday Nov. 30th	Final Exam Logistics + Sample Problem
Friday Dec. 2nd	Test 5
Monday Dec 5th	Diagnostic Part 2: +0.5% on course grade! ATTEND CLASS TO GET BONUS!!
Wednesday Dec. 7th	Bonus Test 5

Assessing the 1st year physics program

Research Study

To improve physics teaching at UBCO, we are doing a two-part diagnostic to:

- help us stay current on what students know coming into the course
- understand the impact of different teaching methods
- assess the quality of the program
- understand how the program serves different populations

Your instructor (me) will not see the results until final exam grades have been submitted!

This diagnostic is NOT FOR MARKS!

You do NOT need to study as this is just a baseline for how you think.

Incentive: 0.5% per diagnostic

Diagnostic (Part 2) will happen in class next Monday (about 45 mins)

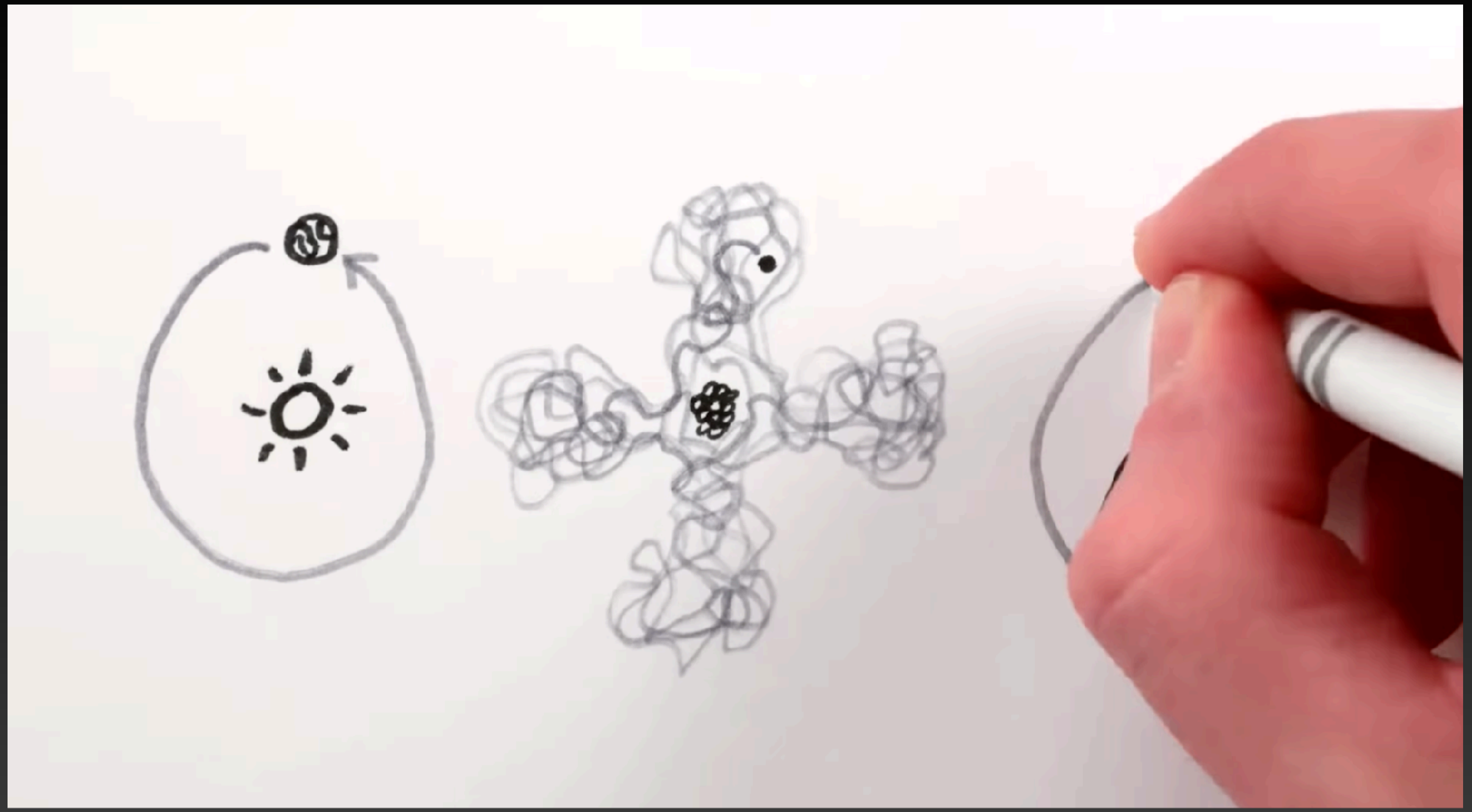
Problem Review Session

Problem Review Session	What we're doing	What you need to do
Part 1 on Zoom **Tuesday Dec 6th, 2022** **3:00 PM - 4:30 PM (will be recorded)** **Link on Canvas > Zoom**	Topics from Weeks 1 - 7 Math, Vectors, Kinematics, Forces, Application of Forces	On Ed Discussion, respond to the thread with question you would like me and the TAs to go over. Qs can be from Tests, HW, Tutorials, Textbook, Online, etc... but must be submitted in advance!
Part 2 on Zoom **Thursday Dec 8th, 2022** **2:00 PM - 3:30 PM (will be recorded)** **Link on Canvas > Zoom**	Topics from Week 8-13 Energy, Momentum, Rotational Motion, Angular Momentum	Same as above!

Monday's Class

11.2 Angular Momentum
11.3 Conservation of Angular Momentum

Angular Momentum



Link to Video

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

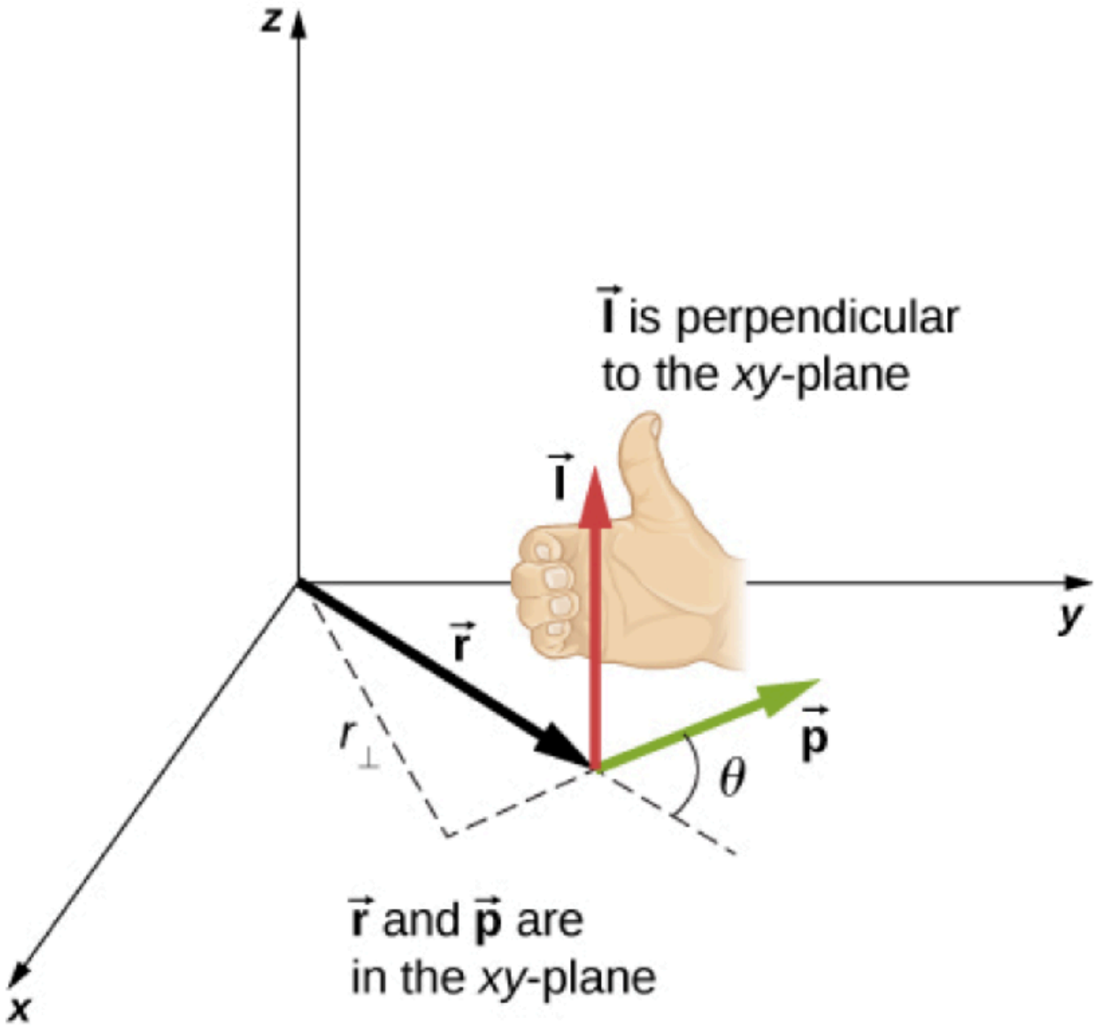


Figure 11.9 In three-dimensional space, the position vector $\vec{\mathbf{r}}$ locates a particle in the *xy*-plane with linear momentum $\vec{\mathbf{p}}$. The angular momentum with respect to the origin is $\vec{\mathbf{l}} = \vec{\mathbf{r}} \times \vec{\mathbf{p}}$, which is in the *z*-direction.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

PROBLEM-SOLVING STRATEGY

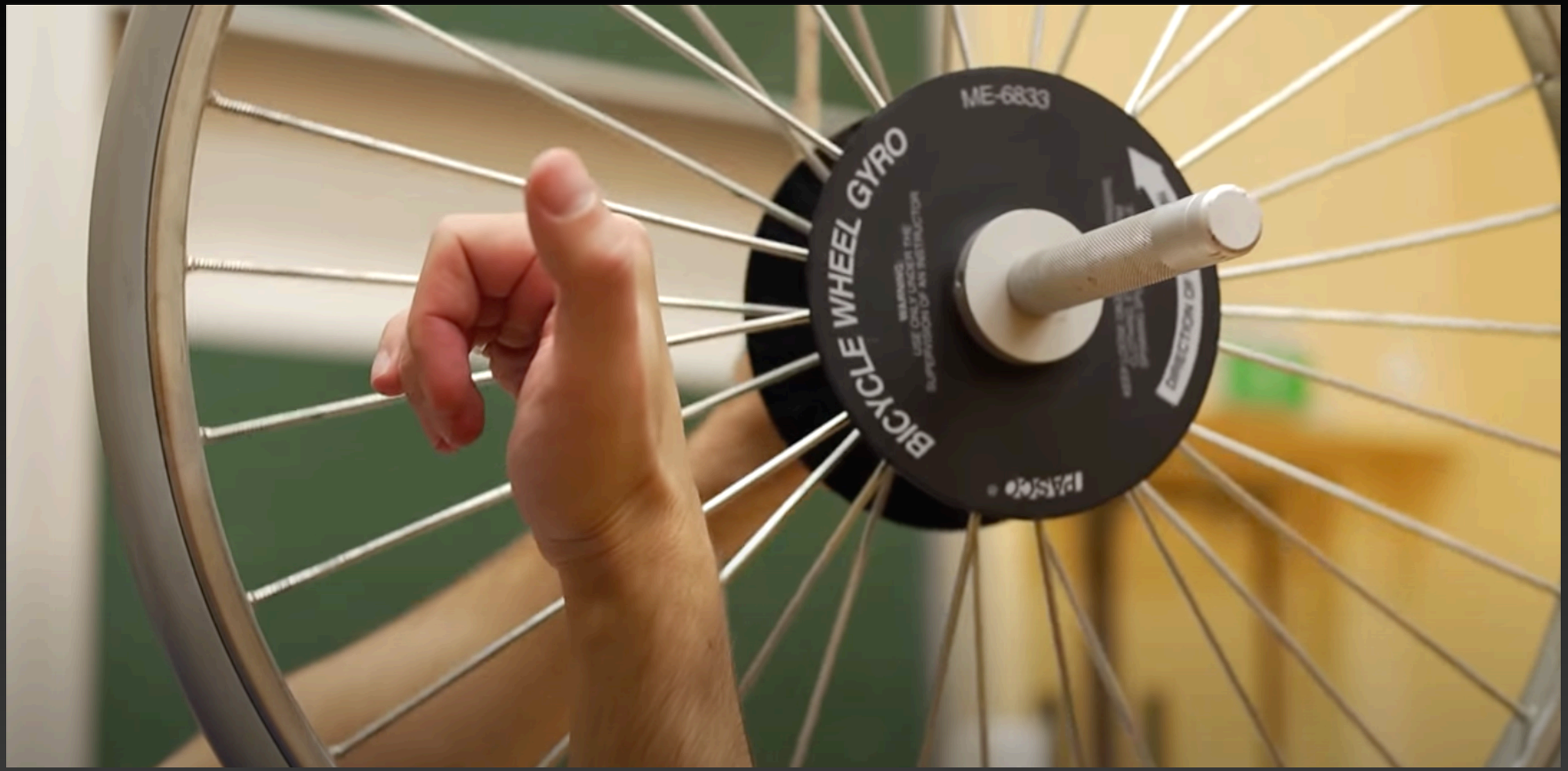
Angular Momentum of a Particle

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**

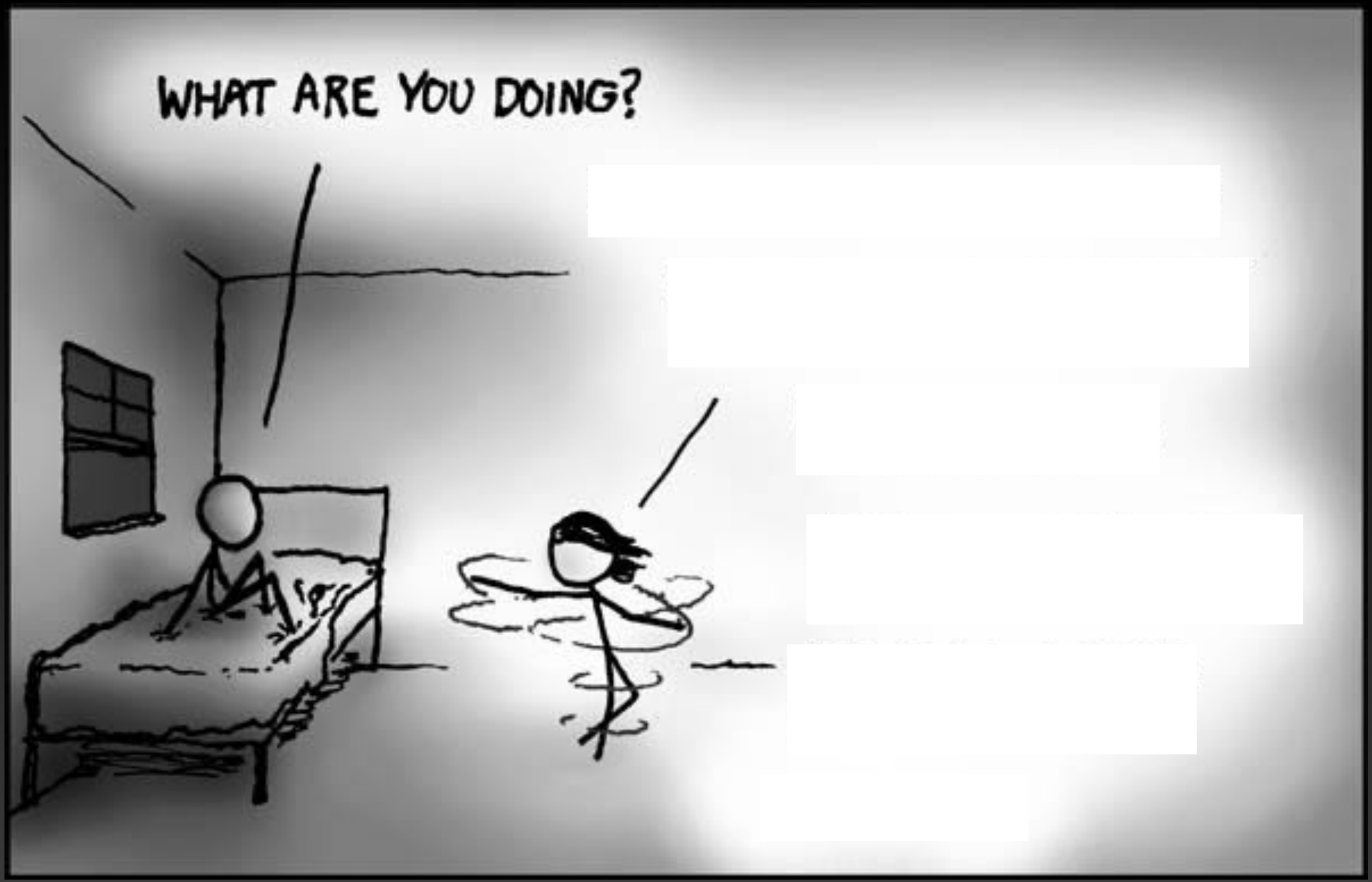
Gyroscopic Precession



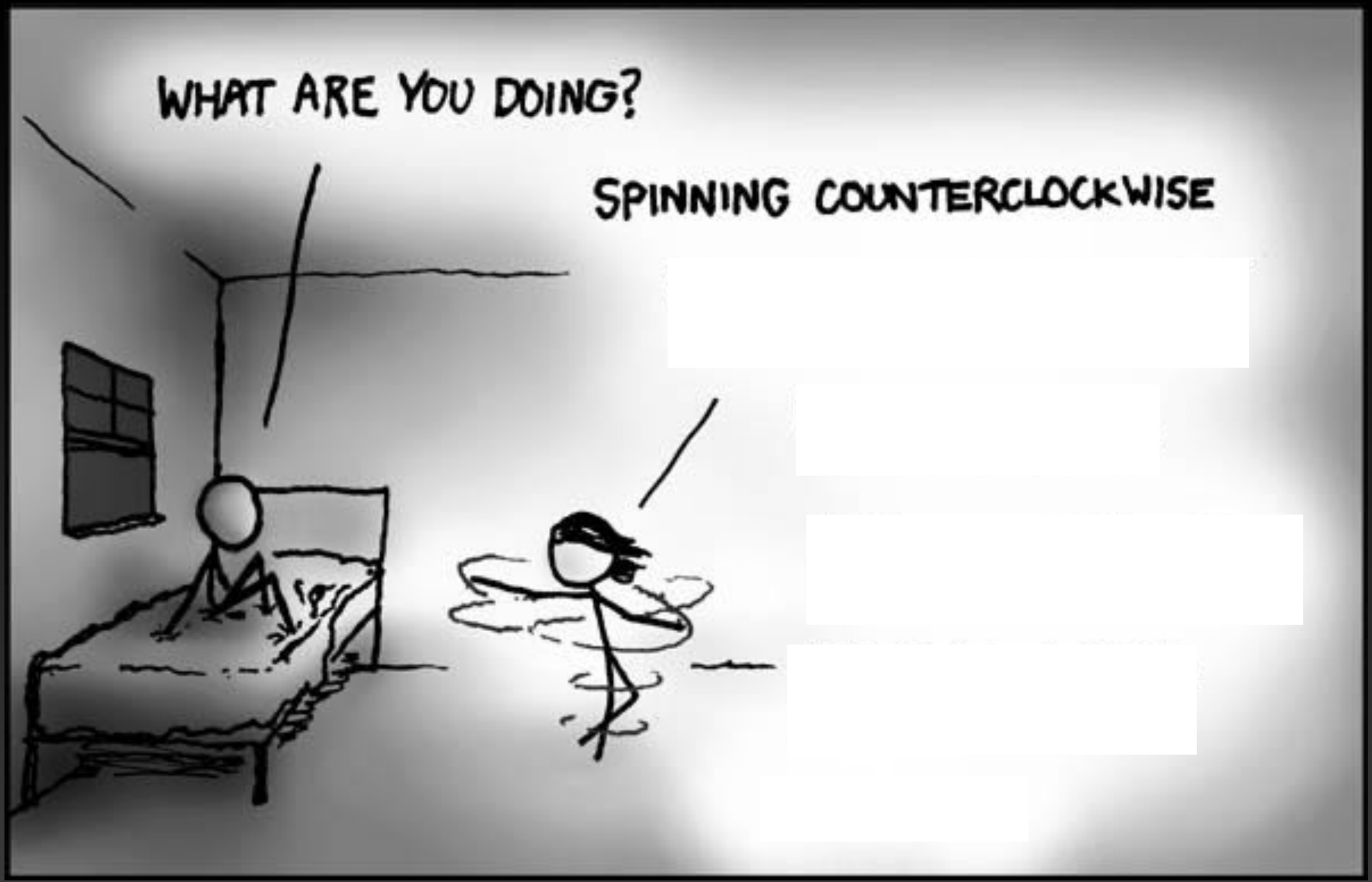
Link to Video

Angular Momentum Mystery?

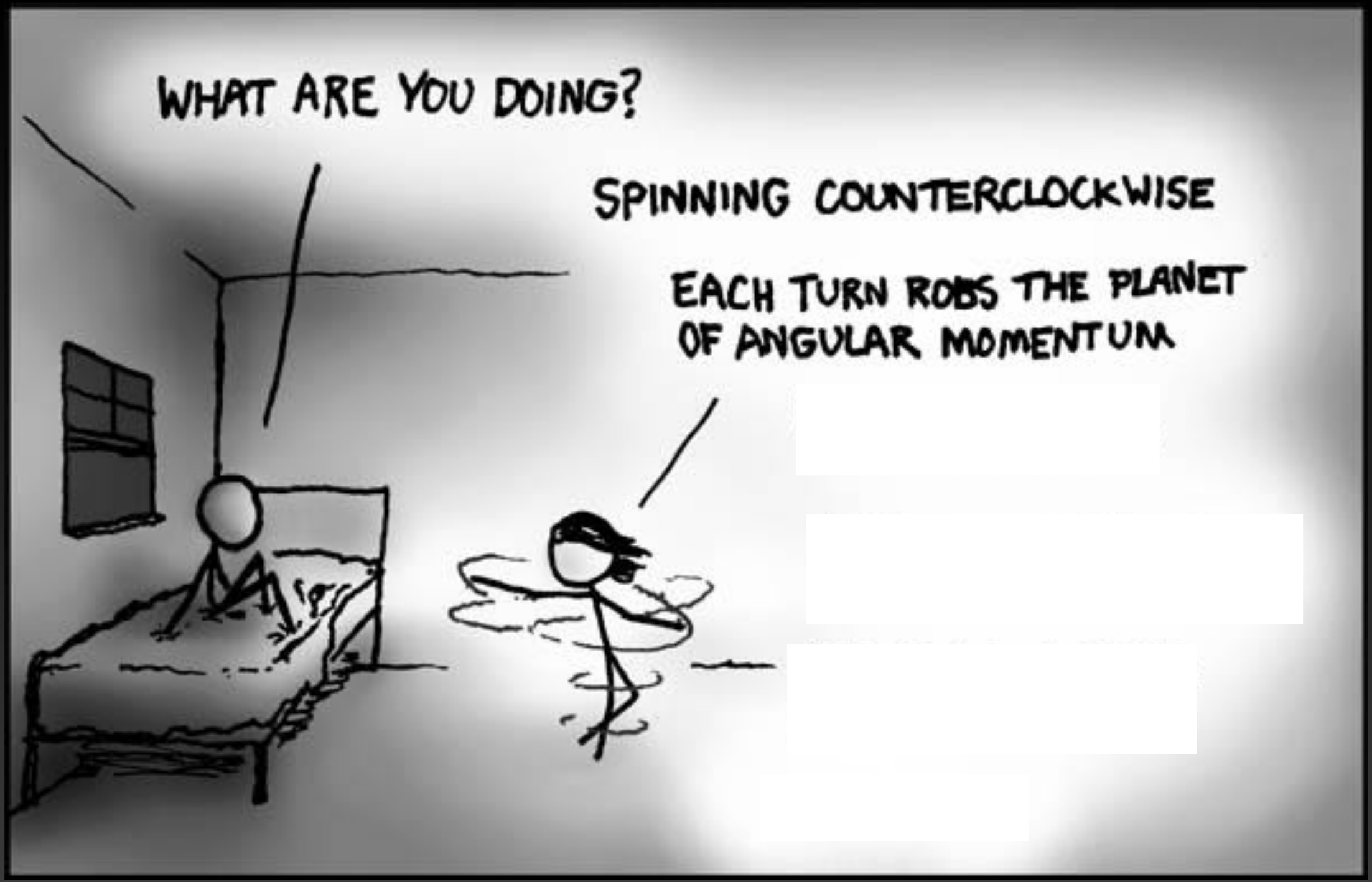
Link to Video



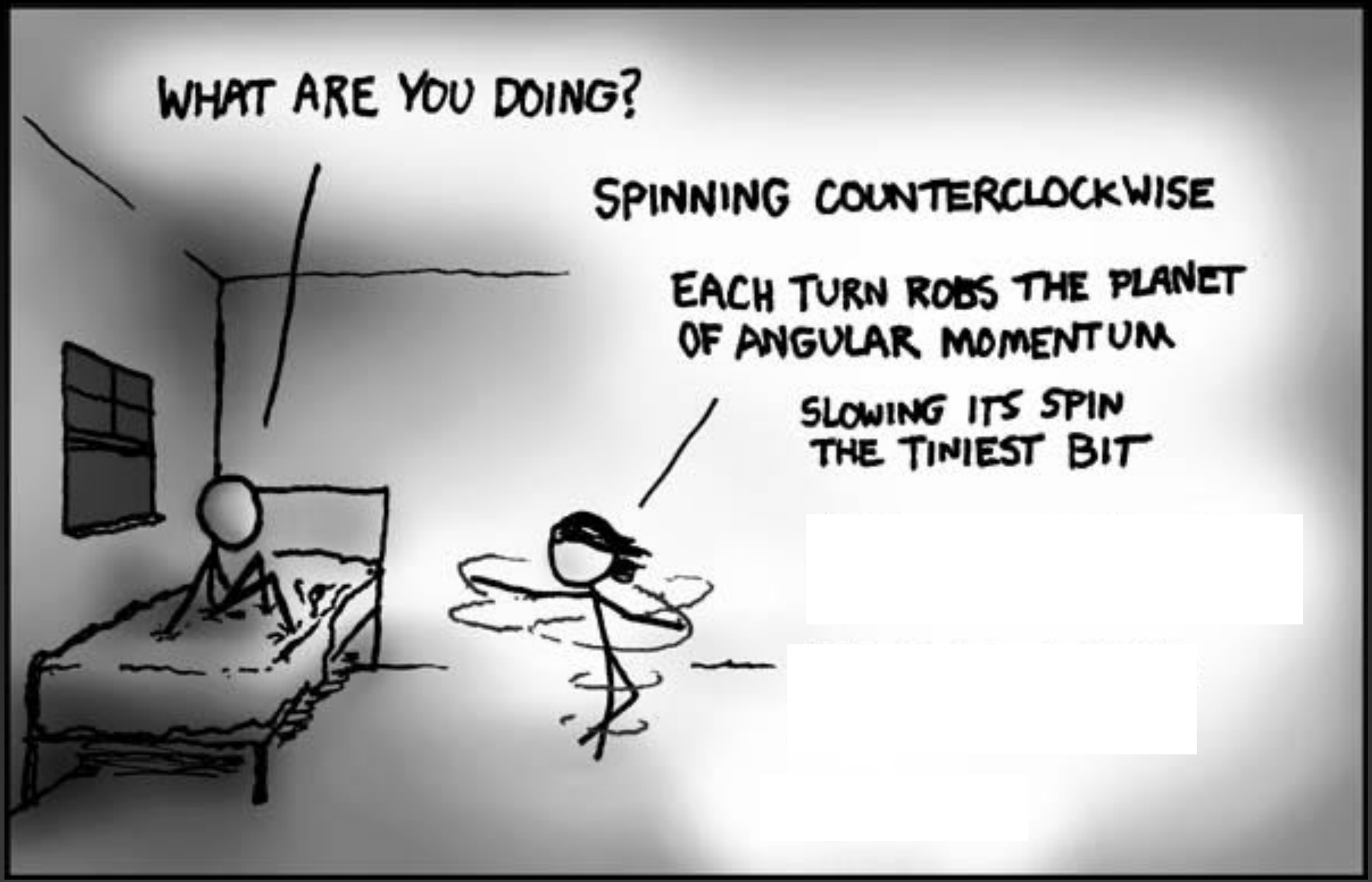
XKCD 162



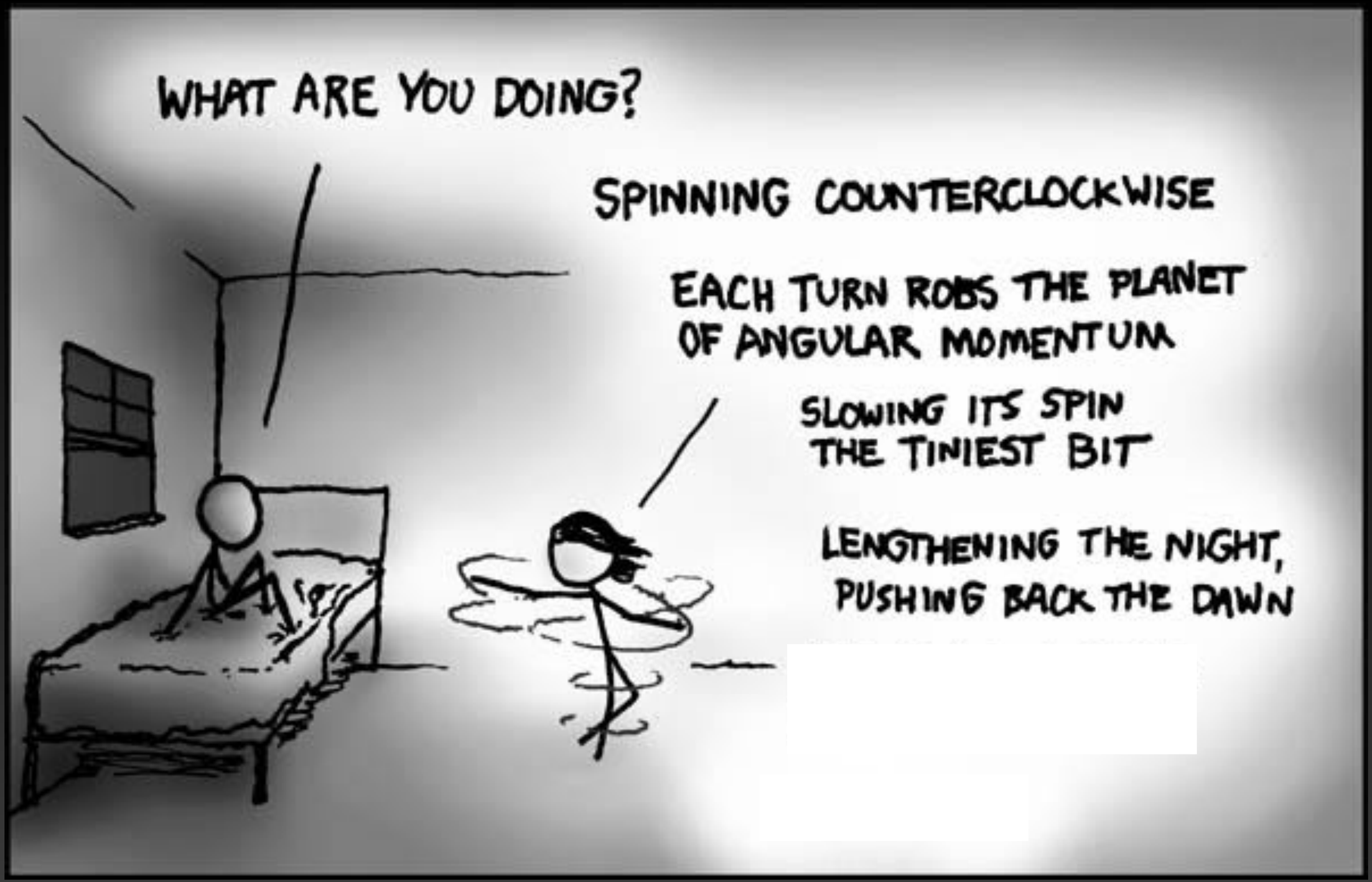
XKCD 162


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

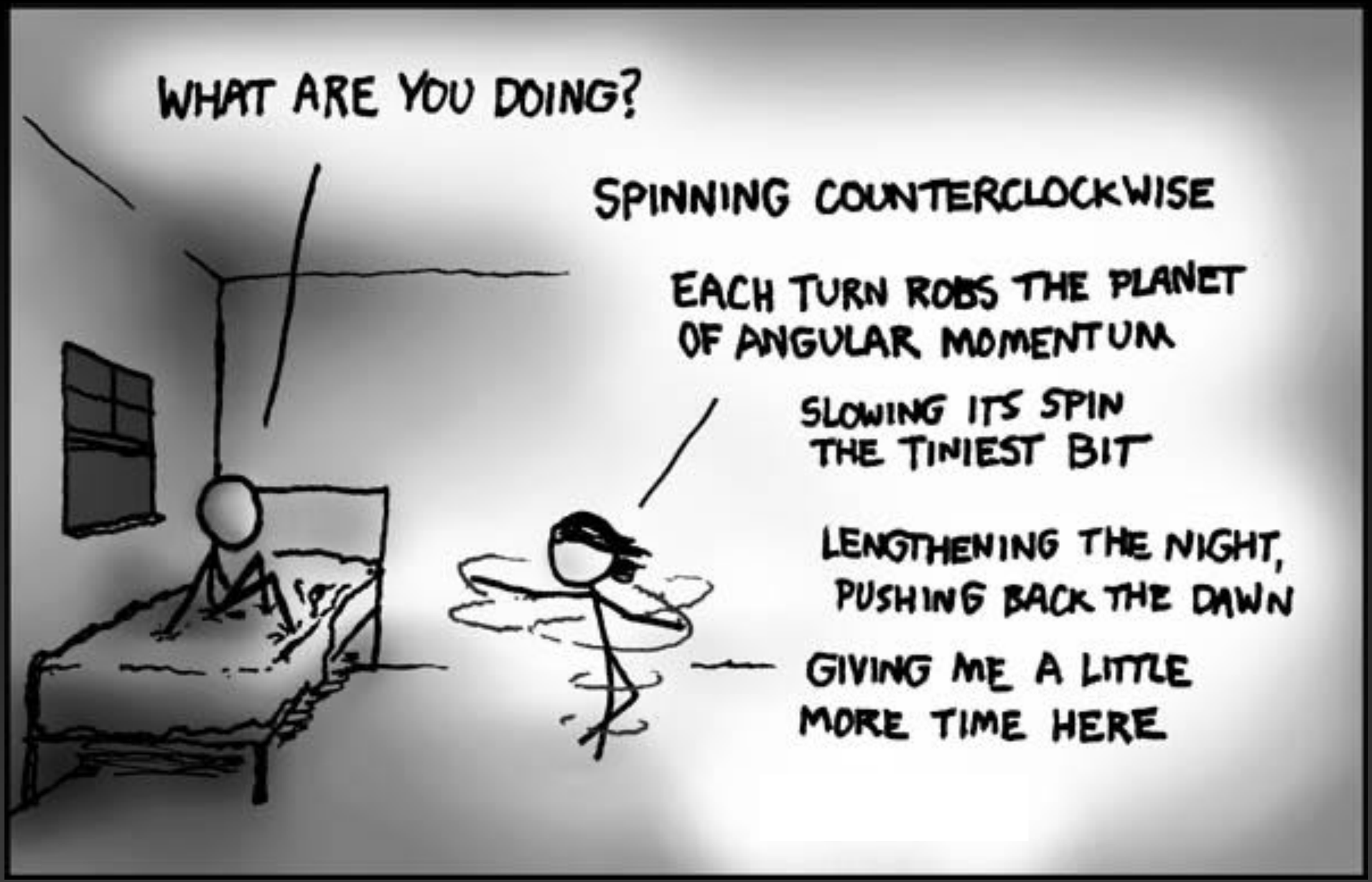
XKCD 162


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

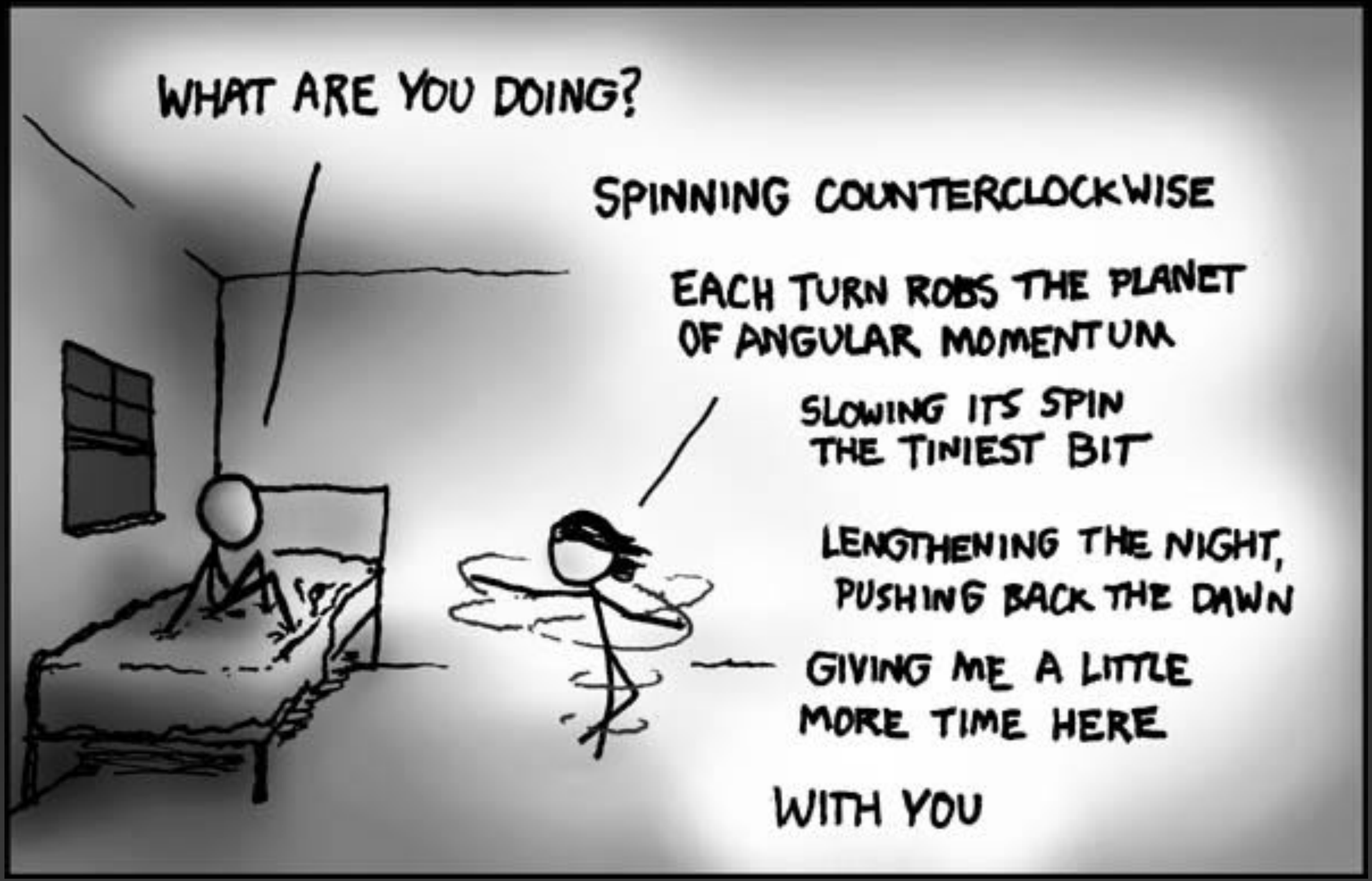
XKCD 162


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 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 ——