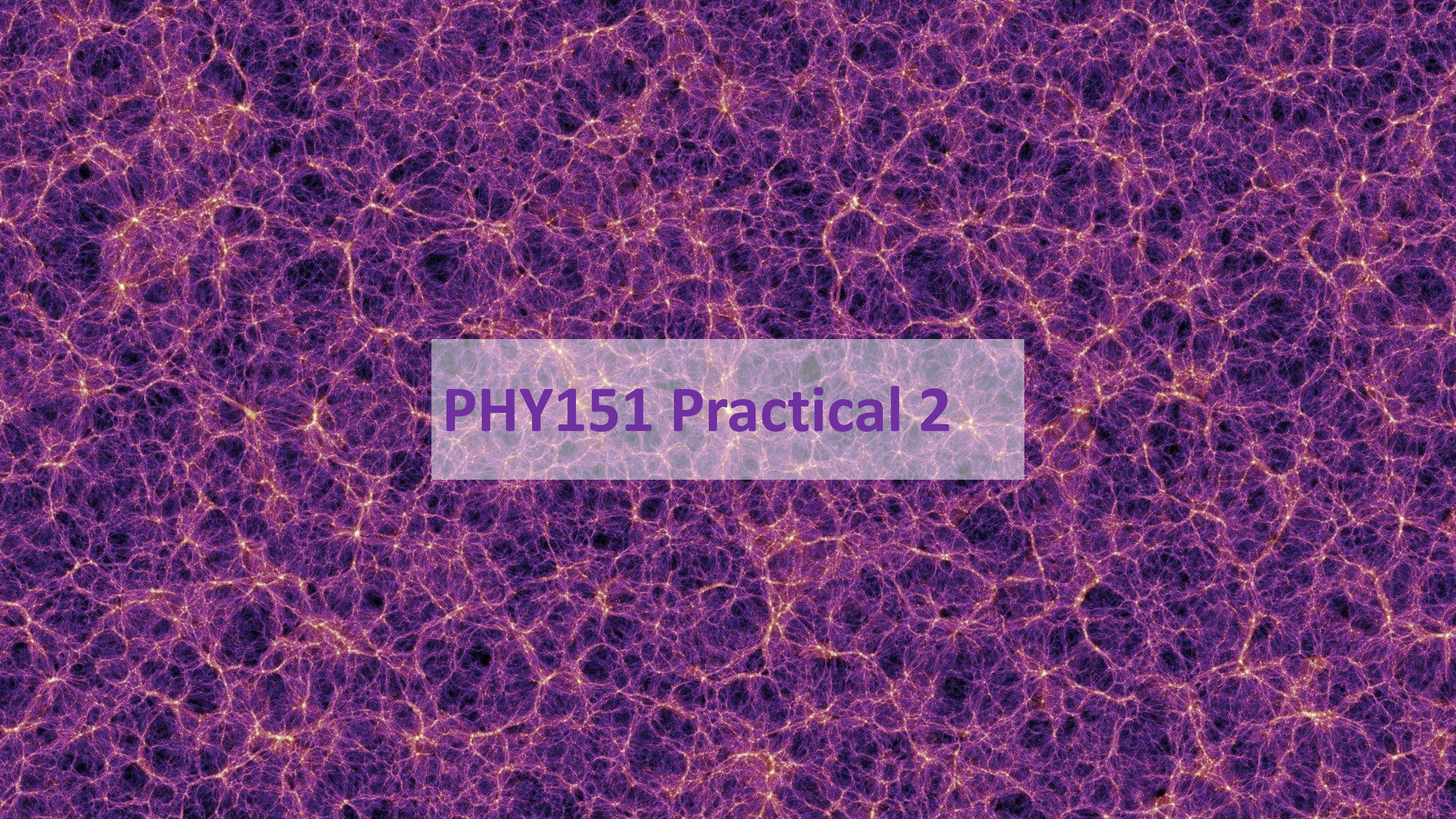
PHY151 Practical 2

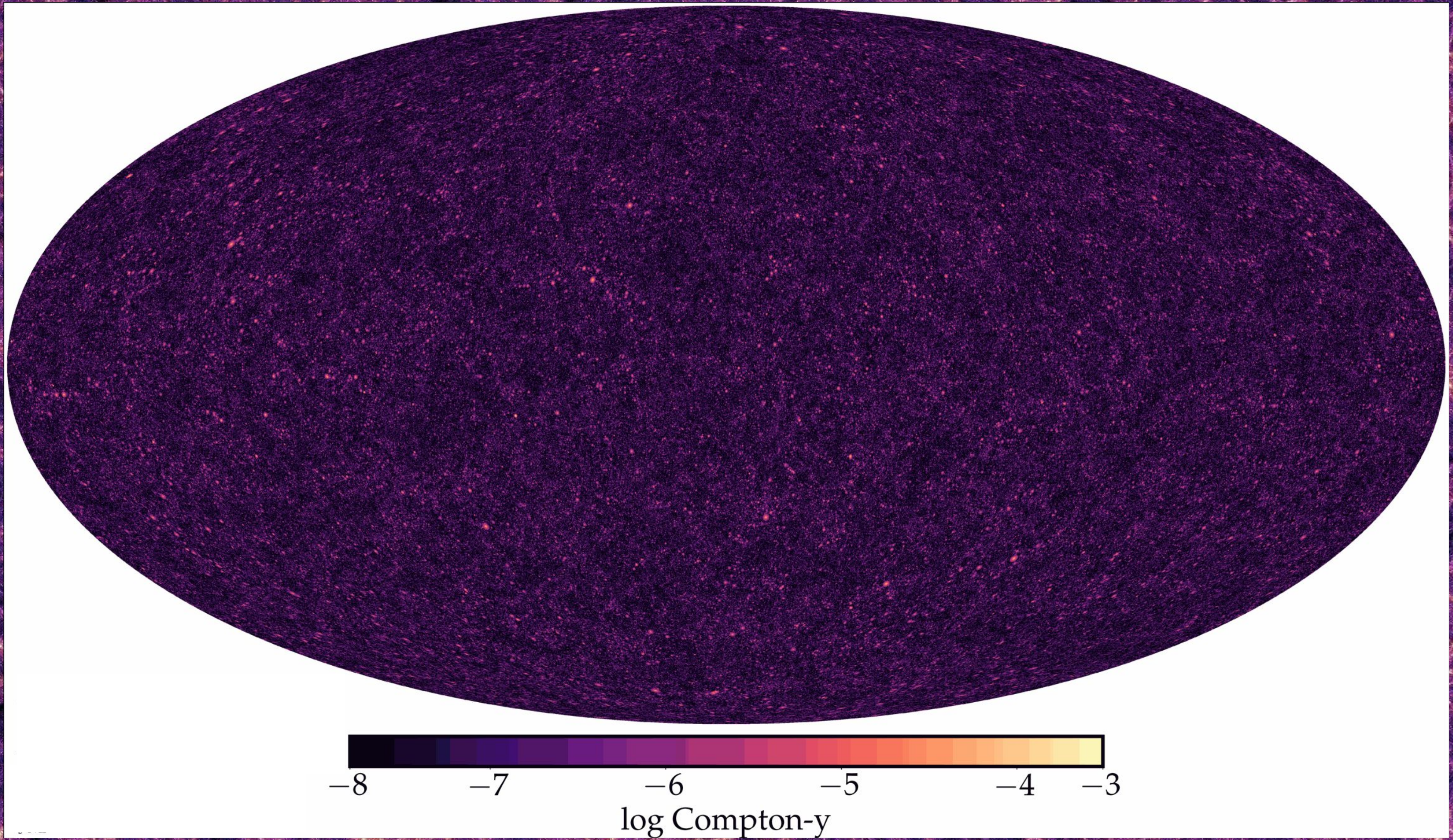


TA: Nathan Carlson

njcarlson@physics.utoronto.ca

Who is this person and why wasn't he here last week?

Hi everyone, I'll be one of your two regular TAs for this semester. I missed last week because of a conference. I am a PhD student in physics/CITA studying cosmology.



Physics
UNIVERSITY OF TORONTO

CITA ICAT
Canadian Institute for Theoretical Astrophysics
L'institut Canadien d'astrophysique théorique

Outline for Today

- First 50 minutes: Practice problems – Prof. Wilson has given us a list of 4 problems he says are similar to ones he may put on Term Test 1. Please work ***together*** on these – ***not for marks!***
- Final 2 hours: working on the Practical Activities of the week. Students complete write-ups in the TERM booklets **for marks**. Mechanics Module 2, Activities 14, 15, and 7 if you have time

Today’s Tutorial Problems

For 1, remember that angular velocity and acceleration are mathematically similar to their linear counterparts.

For 2, what is the **acceleration**? Remember that net force is mass time acceleration, and net force is the sum of all force vectors.

Today's Tutorial Problems

1. $\alpha = \frac{\Delta\omega}{\Delta t} = 0.40\,\text{rotations/sec}$

   $\Delta\theta = \frac{\omega_f^2 - \omega_i^2}{2\alpha} = 15$ rotations.

   (Or constant acceleration means the average rotation is 3 rotations per second, so 5 seconds gives 15 rotations.)

   $d = 2\pi r \times 15 = 39\,\text{m}$

Remember that angular velocity is the derivative of angle, and angular acceleration is the derivative of angular velocity. This works the same way as linear position, velocity and acceleration.

Solve for number of rotations and then multiply by circumference to get distance travelled.

2. $T\cos 35 - \mu n = 0$

   $n + T\sin 35 - mg = 0$

   $T\cos 35 = \mu(mg - T\sin 35)$

   $T(\cos 35 + \mu\sin 35) = \mu mg$

   $T = \frac{\mu mg}{\cos 35 + \mu\sin 35} = 134\,\text{N} = 130\,\text{N}$

Remember that friction force is the coefficient of friction times the normal force.

Start with F = ma where the net force F is the sum of all forces. Break this into x and y components. Use what we know about acceleration to solve for normal force in y component, then solve for T in x component.

Today's Tutorial Problems

3. Set the origin at the bottom of the hill, where you throw the rock. Assume the initial height of the rock is negligible.

   Let the angle of the hill be ϕ. The equation for the hill is $y = x \tan \phi$.

   The equation for the projectile motion is

   $y(x) = x \tan \theta - x^2 \frac{g}{2v_0^2 \cos^2 \theta}$

   where θ is the angle measured from the horizontal (not from the hill) at which the rock is initially thrown (i.e. initial velocity direction).

   The projectile hits the hill where

   $x \tan \phi = x \tan \theta - x^2 \frac{g}{2v_0^2 \cos^2 \theta}$

   with values $x = 0$ (ignore this) and

   $x = (\tan \theta - \tan \phi) \frac{2v_0^2 \cos^2 \theta}{g} = \frac{2v_0^2}{g} \cos^2 \theta (\tan \theta - \tan \phi)$

   The largest range is found by finding θ such that $\frac{dx}{d\theta} = 0$. The constant $\frac{2v_0^2}{g}$ doesn't matter.

   $0 = \frac{dx}{d\theta} = \sec^2 \theta \cos^2 \theta + (\tan \theta - \tan \phi)(-2 \cos \theta \sin \theta)$

   $1 = \sin(2\theta)(\tan \theta - \tan \phi)$

   Note: if you tilt your coordinates to line up with the hill and define the angle $\beta = \theta - \phi$, you can get the nicer equation $\beta = 45 - \phi/2$.

Today's Tutorial Problems

4. Assume the throw is around 40 m/s and the ball curves by about 30 cm. The ball is in flight for about 17/40=0.4 seconds. It needs an acceleration of $a = \frac{2\Delta s}{t^2} \sim 3\,\mathrm{m/s^2}$. That's about a third of the force of gravity, so the air is clearly not negligible here.

   More generally, without the air the ball cannot curve, so clearly the air is necessary for this effect to happen.

   Reasonable speed estimates are 35 to 50 m/s. Reasonable curve estimates are 10 cm (diameter of the ball/bat) to maybe 50 cm. The force should be smaller than g, but at least 5% of g or so.

Another clever way of doing this that a group in a previous section told me about was using angular momentum, where the rotational angular momentum of the ball is converted into an angular momentum of its trajectory. The point is to think about what might be reasonable, not to get "the right answer" in these sorts of problems.

Today’s Practical Activities

Today we’re working on **Mechanics Module 2: Activities 14, 15** and 7 if you have time.

Read the manual carefully! Make sure not to miss steps like levelling your track and zeroing the spring scale!

Remember that all values you measure should have an uncertainty! Some uncertainties come from the smallest scale margin on your measuring device, some come from statistics (recall standard deviation from last week…)