Physics 121 – November 16, 2017

Announcements:

No labs or recitations next week (Thanksgiving)

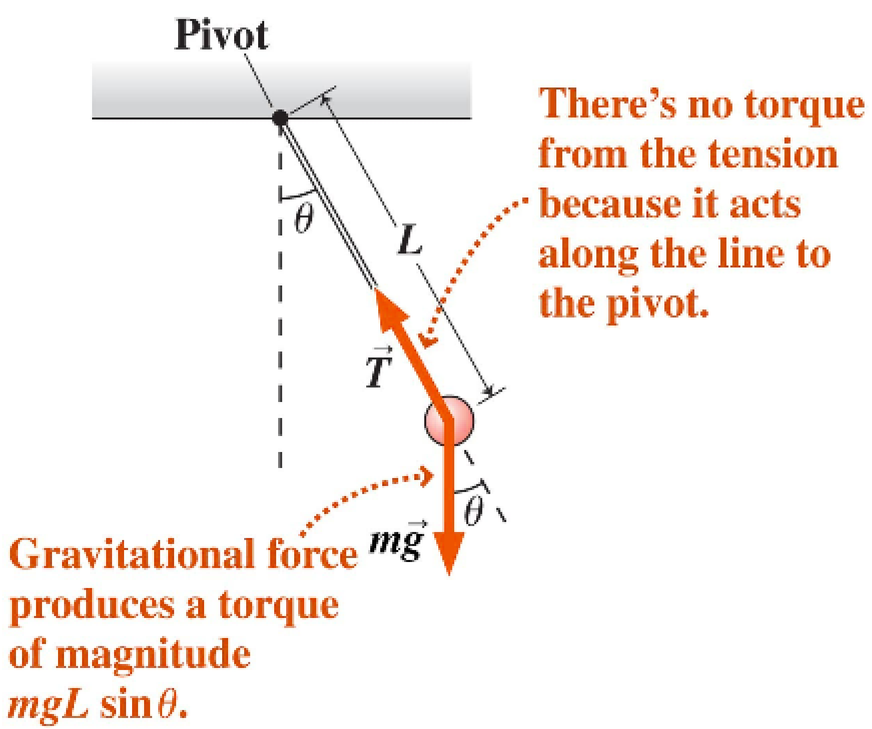
Assignments:

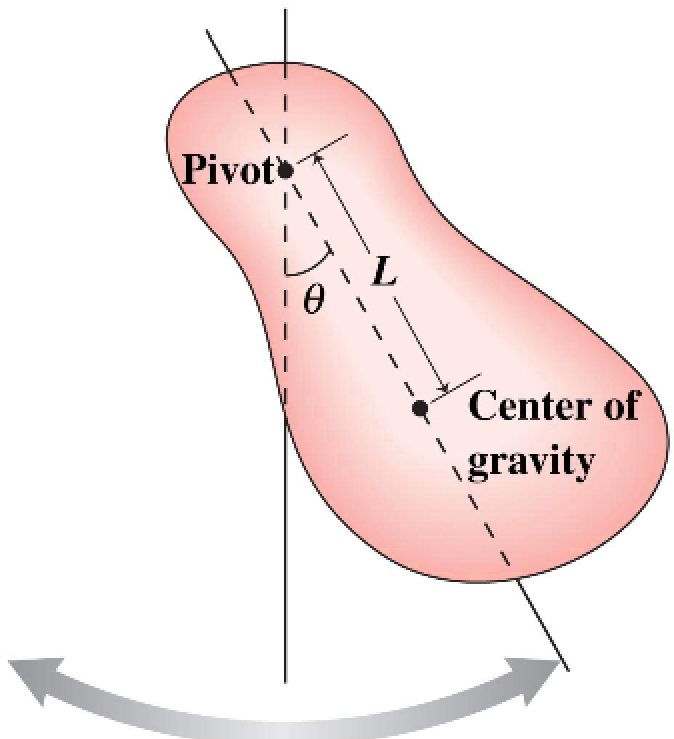
This week:

- Read Chapter 15.
- Complete ETA Problem Set #12 by Monday, Nov 20.
- End-of-chapter problems: Ch 15: 26, 36, 38, 50, 51, 52. Due by 4 pm, Nov 20.
- Recitation: Quiz (statics and torque). Practice problems on harmonic motion.

Simple Pendulum

Physical Pendulum





Point mass suspended from a massless string

Arbitrary shape that's free to swing.

Recall from Tuesday's class

For simple pendulum, all mass is located a distance L from pivot.

Then $I = mL^2$, so $\omega = \sqrt{\frac{g}{L}}$

Example: $L = 1\,m$. $\omega = \sqrt{\frac{9.8\,m/s^2}{1\,m}}$

$\omega \sim 3.2\ rad/s$

$T = \frac{2\pi}{\omega} \simeq 2\ s$

For meter stick,

$f = \frac{10\ \text{cycles}}{17\ \text{sec}} \simeq 0.6\ \text{cycles}/s$

$T = \frac{1}{f} = 1.7\ s$ (less than 2 s)

Let’s look at an ETA problem, and try using clickers.

Then investigate the impact of changing mass and length on simple pendula.

What about changing the mass on a spring system?

What happens if we hook two springs in series, or in parallel?

Torsional Pendulum

A **torsional pendulum** consists of a rigid body suspended by a light wire or spring (Figure 15.22). When the body is twisted some small maximum angle (Θ) and released from rest, the body oscillates between $(\theta = +\Theta)$ and $(\theta = -\Theta)$. The restoring torque is supplied by the shearing of the string or wire.

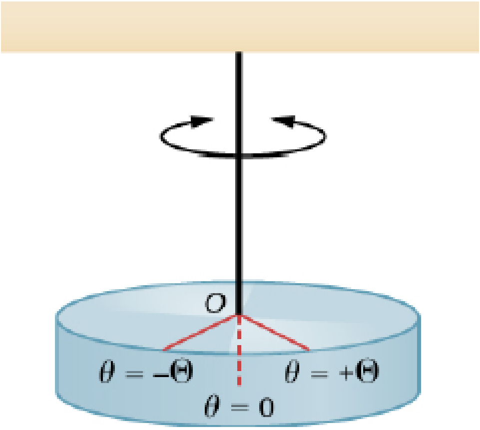


Figure 15.22 A torsional pendulum consists of a rigid body suspended by a string or wire. The rigid body oscillates between $\theta = +\Theta$ and $\theta = -\Theta$.

The restoring torque can be modeled as being proportional to the angle:

$$\tau = -\kappa\theta.$$

The variable kappa (κ) is known as the torsion constant of the wire or string. The minus sign shows that the restoring torque acts in the opposite direction to increasing angular displacement. The net torque is equal to the moment of inertia times the angular acceleration:

$$I\frac{d^2\theta}{dt^2} = -\kappa\theta;$$

$$\frac{d^2\theta}{dt^2} = -\frac{\kappa}{I}\theta.$$

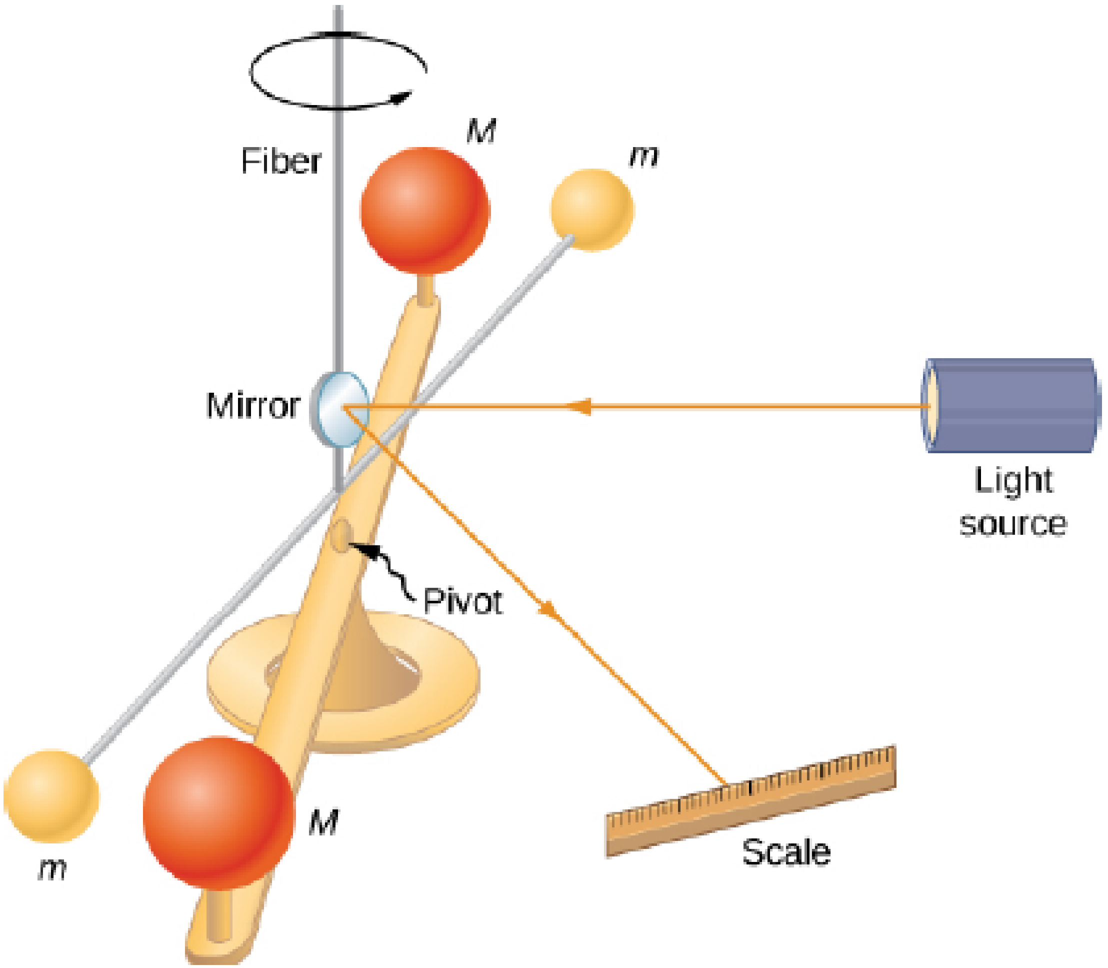


Figure 13.3 Cavendish used an apparatus similar to this to measure the gravitational attraction between two spheres (m) suspended from a wire and two stationary spheres (M). This is a common experiment performed in undergraduate laboratories, but it is quite challenging. Passing trucks outside the laboratory can create vibrations that overwhelm the gravitational forces.

The angular frequency for damped harmonic motion becomes

$$\omega = \sqrt{\omega_0^2 - \left(\frac{b}{2m}\right)^2}. \tag{15.26}$$

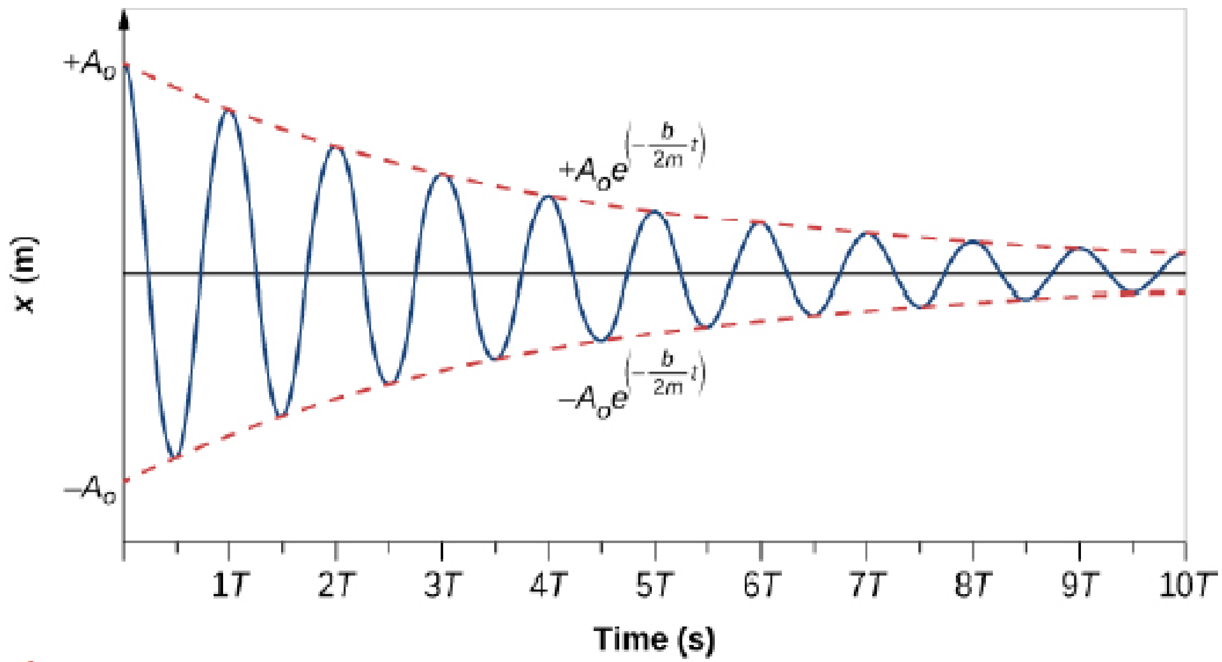


Figure 15.26 Position versus time for the mass oscillating on a spring in a viscous fluid. Notice that the curve appears to be a cosine function inside an exponential envelope.