PHY131H1S - Class 24

Today:

- Course Review!

- The final exam, will be on Wednesday April 20 at 9:00am in BN3. (two weeks from today)

- Note there are no practicals this week.

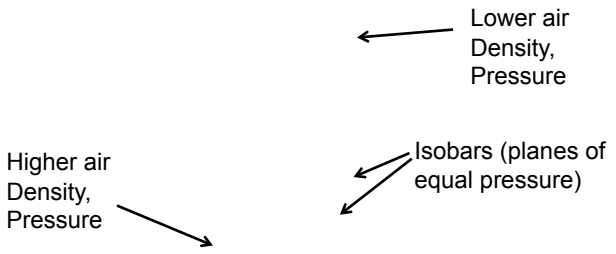
- The final exam will cover Chapters 1-15, excluding unlucky Chapter 13 and the last 2 sections of chapter 15. The final exam will also cover the Error Analysis Mini-version document you were asked to read.

- You are allowed TWO double-sided aid-sheets for the final exam, which you must prepare yourself.

- A cart is covered by an enclosed transparent box. A ball is attached to the top of the box by a string. Predict: As the box is accelerating toward the right, which will be the best sketch of the situation?

- A cart is covered by an enclosed transparent box. A helium-balloon is attached to the bottom of the box by a string. Predict: As the box is accelerating toward the right, which will be the best sketch of the situation?

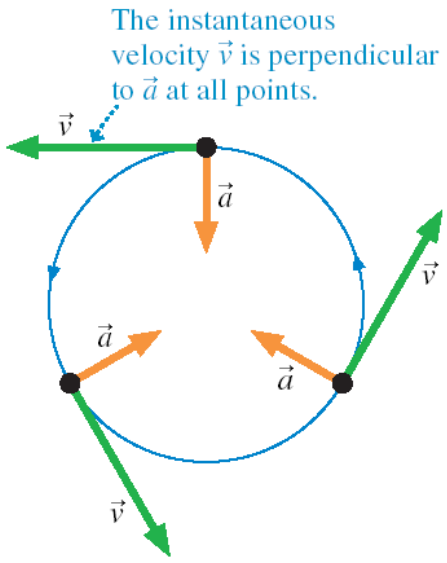
As the cart accelerates to the right, the heavier air molecules are left behind, to the left, creating a tilted pressure gradient



- Another way of looking at it: Gravity acts like a pseudo-force, similar to the result of acceleration. This was noted by Einstein and lead to his theory of General Relativity in 1915.

- Einstein's Equivalence Principle states that *"the gravitational 'force' as experienced locally while standing on a massive body (such as the Earth) is actually the same as the pseudo-force experienced by an observer in a non-inertial (accelerated) frame of reference."* http://en.wikipedia.org/wiki/Equivalence_principle

Some Review: Centripetal Acceleration



What is a force?

- A force is a push or a pull on an object.
- A force is a vector. It has both a magnitude and a direction.
- A force requires an agent and a recipient. Something does the pushing or pulling, and something else gets pushed or pulled.
- A force is either a contact force or a long-range force. **Gravity** is the only long-range force we dealt with in PHY131.
- Important contact forces are: **Normal**, **Tension** and **Friction (static and kinetic)**.

Isaac Newton

- 1643-1727
- According to wiki, was a "physicist, mathematician, astronomer, natural philosopher, alchemist, and theologian and one of the most influential people in human history."

  In *Philosophiæ Naturalis Principia Mathematica*, published 1687, he described **universal gravitation** and the **three laws of motion**, laying the groundwork for classical mechanics.

If no force:

Newton's first law is also known as the law of inertia. If an object is at rest, it has a tendency to stay at rest. If it is moving, it has a tendency to continue moving with the same velocity.

If object is forced:

Newton's second law An object of mass m subjected to forces $\vec{F}_1$, $\vec{F}_2$, $\vec{F}_3$, . . . will undergo an acceleration $\vec{a}$ given by

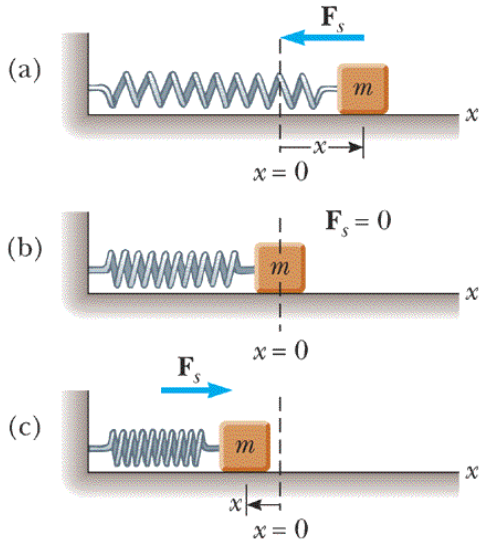
$$\vec{a} = \frac{\vec{F}_{\text{net}}}{m} \qquad (5.4)$$

where the net force $\vec{F}_{\text{net}} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$ is the vector sum of all forces acting on the object. The acceleration vector $\vec{a}$ points in the same direction as the net force vector $\vec{F}_{\text{net}}$.

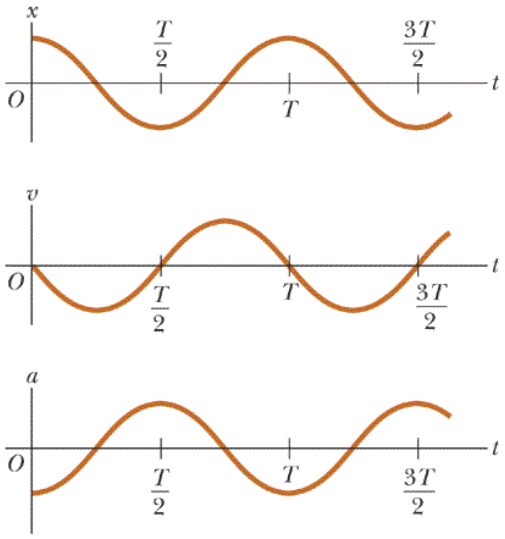
Bob stands under a low concrete arch, and presses upwards on it with a force of 100 N. Bob's mass is 82 kg. What is the **normal force** of the arch on Bob?

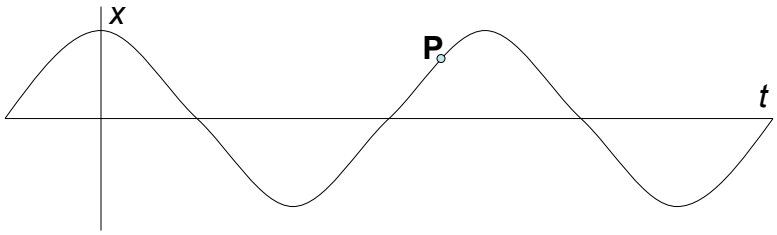
Bob stands under a low concrete arch, and presses upwards on it with a force of $100\ \mathrm{N}$. Bob's mass is $82\ \mathrm{kg}$. What is the **normal force** of the ground on Bob? (Note that 82 × 9.8 = 800.)

Simple Harmonic Motion: Restoring Force provided by Hooke's Law



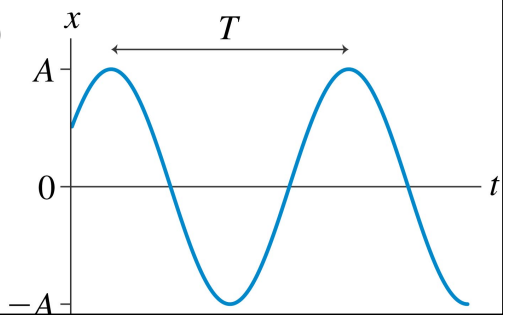
x,v,a for Simple Harmonic Motion





Simple Harmonic Motion notes…

- S.H.M. is *not* constant acceleration, or constant force – both vary with time.
- S.H.M. results when restoring force is proportional to displacement. Other types of oscillatory motion are possible, but not discussed in this course.
- Angular frequency $\omega = 2\pi/T$, where T = period.
  ($T = 2\pi/\omega$)
- "frequency" $f = 1/T$ (in Hertz)



Gravitational Field Note: Prep for PHY132

- When a mass m is near the surface of the Earth, it has a potential energy, given by

$$U_g = mgy + U_0$$

- where y is the vertical height, and U_0 is an arbitrary constant, in Joules.
- Since m is so much smaller than the mass of the Earth, we can think of m as a "test particle".
- No matter where we place m, it has a gravitational potential energy due to the Earth.
- We can think of this as a property of the space itself: the gravitational potential energy field.
- This is a scalar field: a number is associated with every (x,y,z) point in space.

Gravitational Field Note: Prep for PHY132

- Recall from section 11.6, eq.11.28: The Force on an object is the negative of the gradient of its potential energy.

$$\vec{F}_g = -\vec{\nabla}U_g = -\left(\frac{\partial U_g}{\partial x}\hat{x} + \frac{\partial U_g}{\partial y}\hat{y} + \frac{\partial U_g}{\partial z}\hat{z}\right)$$

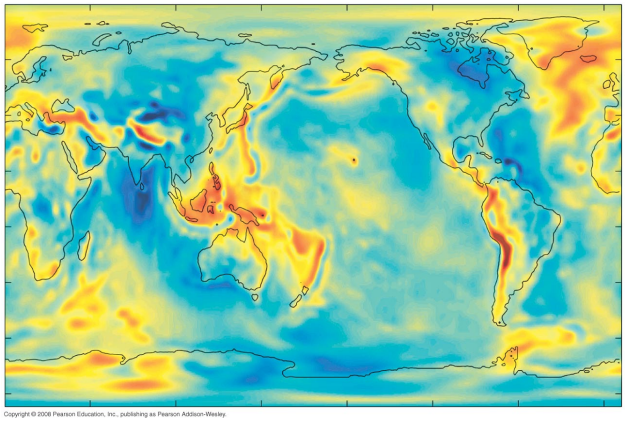
$$\vec{F}_g = -\left[\frac{\partial}{\partial y}\left(mgy + U_0\right)\right]\hat{y} = mg, \qquad \text{downward}$$

- No matter where we place m, there is a gravitational force at every point in space due to the Earth, which is the negative gradient of the potential energy.
- We can think of this as a property of the space itself: the gravitational force field.
- This is a vector field. A vector is associated with every (x,y,z) point in space.

The Gravitational Field

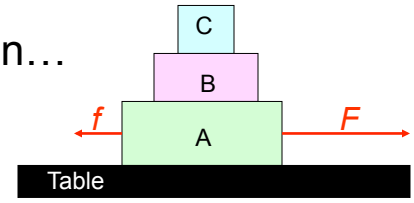
- Equipotential surfaces map where the potential energy is constant.

From Knight Ch.13, pg.393



- An equipotential around the Earth is not quite spherical. It has bumps (red regions) and dips (blue regions)
- The gravitational force vectors are perpendicular to the equipotential surfaces.

A former exam question…



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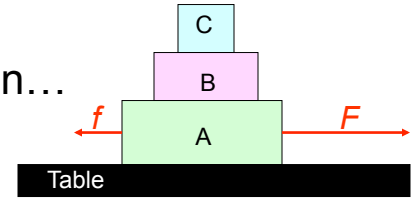

Between now and the Final Exam

- There is a MasteringPhysics Problem Set due tonight. If you haven't already finished it, please submit this by 11:59pm tonight.
- The 3 hour final exam will cover the entire course, including all of the assigned reading plus Practicals materials and what was discussed in class
- Approximately even spread over the course material
- I recommend you be familiar with all Masteringphysics problem sets and all Practicals work you did.
- Please email me (jharlow @ physics.utoronto.ca) with any questions. Keep in touch! It's been a really fun course for me!