“The tendency of modern physics is to resolve the whole material universe into waves, and nothing but waves. These waves are of two kinds: bottled-up waves, which we call matter, and unbottled waves, which we call radiation or light. If annihilation of matter occurs, the process is merely that of unbottling imprisoned wave-energy and setting it free to travel through space. These concepts reduce the whole universe to a world of light, potential or existent, so that the whole story of its creation can be told with perfect accuracy and completeness in the six words: ‘God said, Let there be light’.”

“The Mysterious Universe” by Sir James Jeans, British astronomer (1877-1946)

“For the rest of my life I will reflect on what light is.”

Albert Einstein, German-American physicist (1879-1955).

Current Assignments ...

For today:

- Read 8.6, 9.1, 9.2, 9.3

For Lecture 10:

- Read Sections 9.4 - 9.7

Office hours:
3-4 Tuesdays
& Thursdays

Suggested Conceptual Exercises:

- Chapter 9: 1,3,5,7,9,11,13,19,21,23,29,31,33

Homework #2

- Due 11:00 AM, Thursday, February 14

Writing Assignment #1

- Due 11:00 AM, Thursday, February 28

Tutorials

- Tutorial #4 this week

Review of Lecture 8

Textbook, Sections 8.1, 8.2, 8.3, 8.5, 8.6

- Electricity
- Atoms and electrons
- Force fields
- Magnetism and electromagnetism

Plan for Lecture 9

Textbook, Sections 8.6, 9.1, 9.2, 9.3

- Electromagnetism

- Waves
- Interference of waves
- Light: particle or wave?
- The double slit experiment

From Lecture 8: Fields

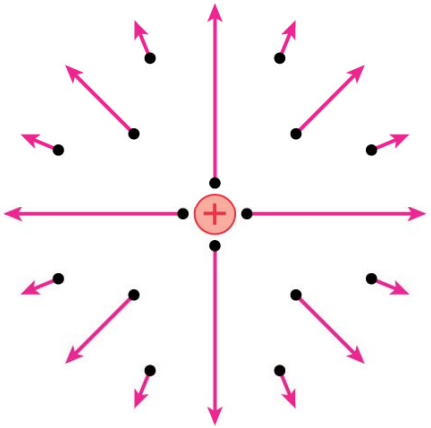
- A field transmits a force:
  - → It is a property of space.
  - → It requires a source.
    e.g., Earth, an electric charge, a magnet
  - → An object placed in a field experiences a force.

Examples of Fields

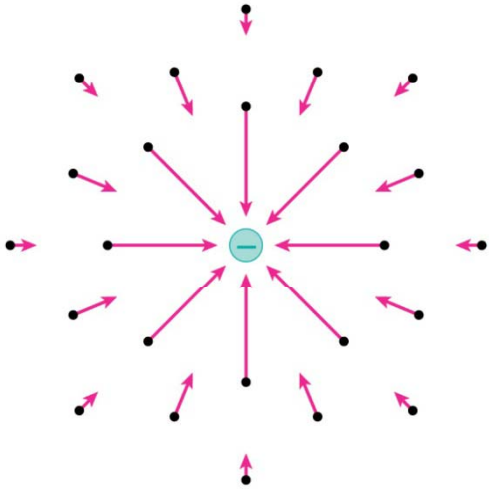
- **Gravitational field** - exists in a region of space where an object would feel a gravitational force if it were placed there.
- **Electromagnetic field** - exists in a region of space where a charged object would feel an electromagnetic force if it were placed there.
- An **electric field** will exert a force on a charge.
- A **magnetic field** will exert a force on a moving charge.

Visualizing Fields

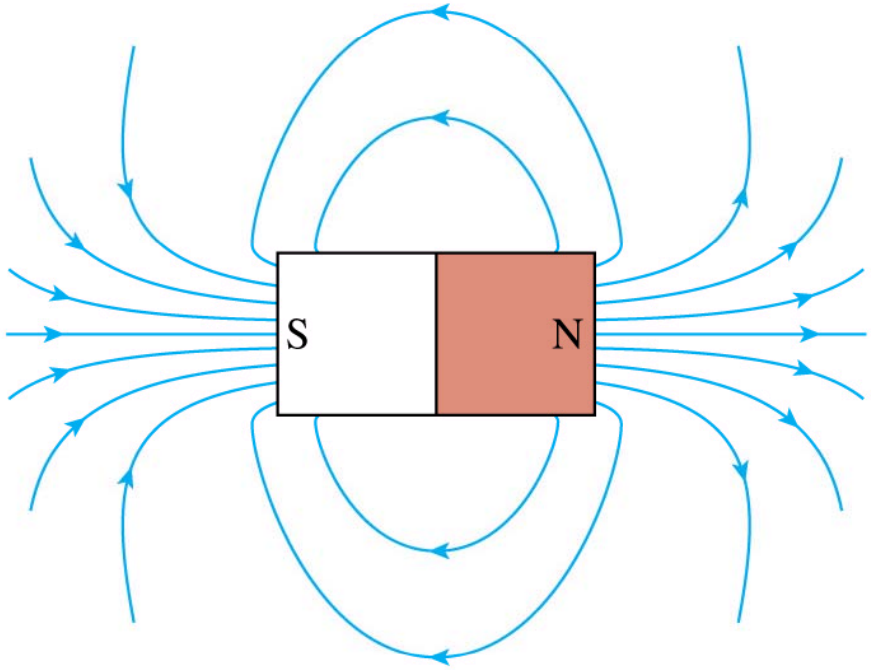
- Field lines show direction the force would be.
- They point in the direction the force would be on a positive charge or a north pole.



Field lines for a positive charge



Field lines for a negative charge

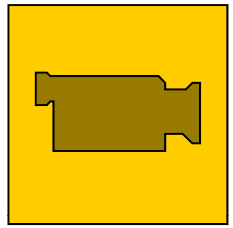


Field lines for a bar magnet

More on Field Lines

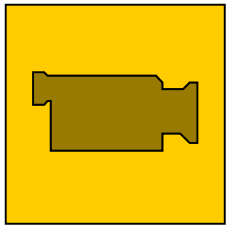
Flash animation of electric field lines:

- http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/EM/FieldLines/FieldLines.html

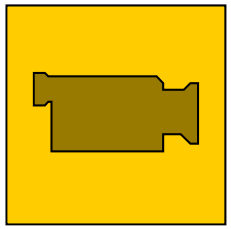


Animations of magnetic field lines:

- http://micro.magnet.fsu.edu/electromag/java/magneticlines/index.html



- http://micro.magnet.fsu.edu/electromag/java/magneticlines2/



The Electric Force Law

restated in terms of fields…

An electric field surrounds every charged object.

Furthermore, any charged object that happens to be located at a point in space where the electric field exists will feel an electric force due to that field.

Briefly, charged objects create electric fields and feel forces due to the electric fields of other charged objects.

The Magnetic Force Law

restated in terms of fields…

A magnetic field surrounds every moving charged object.

Furthermore, any moving charged object that happens to be located at a point in space where a magnetic field exists will feel a magnetic force due to that field.

Briefly, moving charged objects create magnetic fields and feel forces due to the magnetic fields of other moving charged objects.

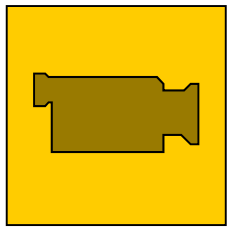
Magnets and Wire Loops

What happens when a magnet and a wire loop are brought together?

- If both are stationary - nothing
- If one is moving …

- http://phet.colorado.edu/simulations/sims.php?sim=Faradays_Electromagnetic_Lab

Try this animation at home



Faraday's Law

- Michael Faraday did this experiment (1831), hence we have Faraday's Law:
- When a wire loop is placed near a magnet and when either the loop or the magnet is moved, an electric current is created within the loop for as long as the motion continues. Stated in terms of fields:
  A changing magnetic field creates an electric field.
- This principle is used in modern electric power generators.

  → Electricity is generated by the rotating of a shaft wrapped in wires located in a magnetic field.

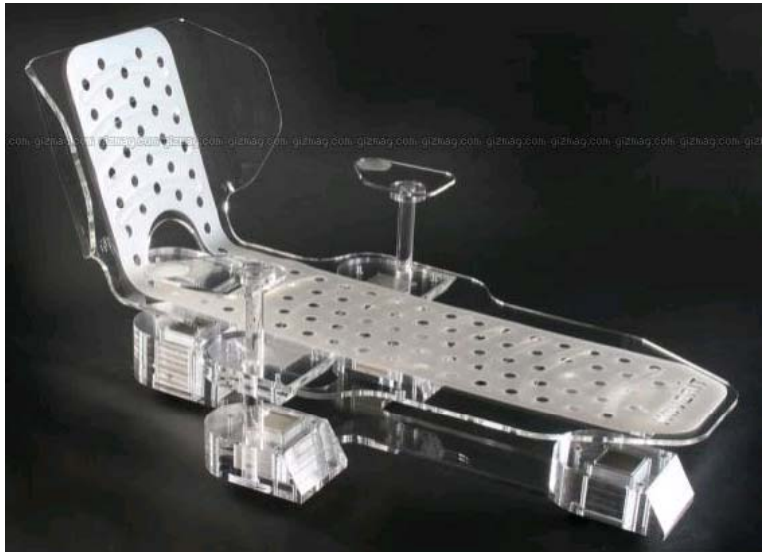
The Globe and Mail, Wednesday, Feb. 6, 2008

MODERN FURNITURE, EH?

British inventor Keith Dixon, 40, is creating a range of household furniture that hovers off the ground to give a feeling of weightlessness. The Lounger, for instance, is an armchair that floats. Magnets in the seat and base repel each other, forcing the seat to float at a height of up to 36 centimetres. It can support a person who weighs 265 pounds. Although there are some claims that magnetic fields can help ease back and muscle pain, Mr. Dixon, who originally trained as a chef, warns that the chair is not to be used by anybody with a pacemaker. It may also affect a nearby television set, discolouring the picture, and if you sit down with your wallet in your pocket, the magnets may wipe your credit cards.

Source: The Sunday Times of London

Inspired by Star Wars...

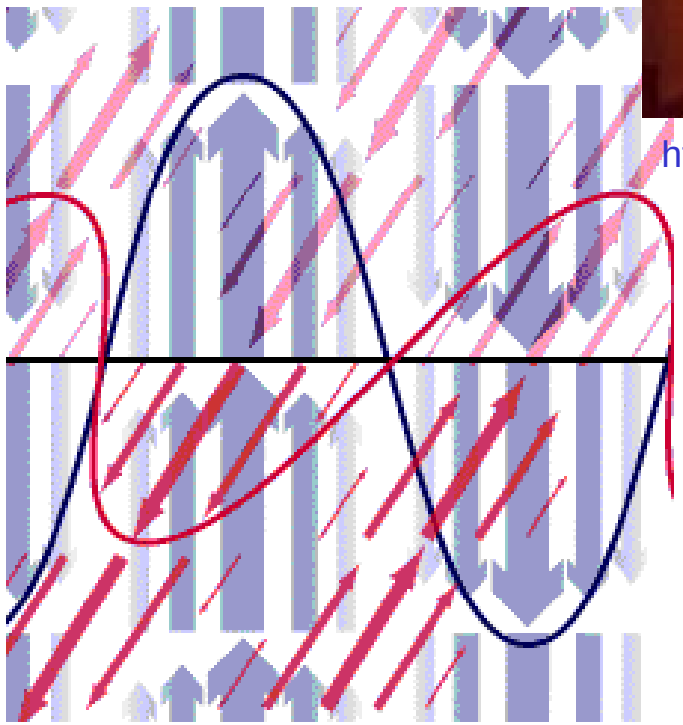


http://www.gizmag.com/the-ukp-5875-magnetic-floating-lounger/8704/

January 24, 2008 We've written before about the EUR 1,200,000 (US$1,750,000) floating bed which uses permanent opposing industrial-strength magnets to enable it to float, so **this exquisite floating lounger is by comparison a bargain basement remainder with pricing starting at GBP 5,875 (US$11,500).** Almost magical with its use of magnetism to offer a genuine floating sensation and no-fixed-means-of-support, it's the ideal thing for a design studio or advertising agency reception area, and **the perfect gift for the person who has everything already.**

Electric and **Magnetic** fields, when oscillated, can create waves which carry energy. At the right frequency, we see electromagnetic waves as **Light**.

http://www.amasci.com/emotor/vdg.html



What Is a Wave?

- **A wave is a disturbance that travels through a medium in such a way that energy travels through the medium but matter does not.**

Textbook Figure 9.2

- In a wave, particles of the medium are temporarily displaced and then return to their original position.

Transverse Waves

- In a **transverse wave**, particles of the medium are displaced in a direction perpendicular to the direction of energy transport.
- Each point moves up and down.

Textbook Figure 9.4

Longitudinal Waves

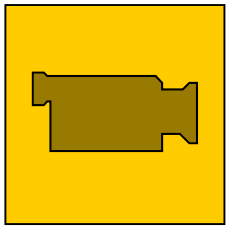
- In a **longitudinal wave**, particles of the medium are displaced in a direction parallel to energy transport.
- Each point moves back and forth.

Textbook Figure 9.3

Two Types of Waves

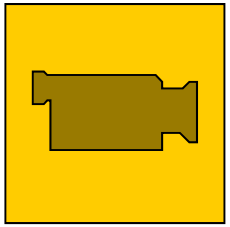
Transverse and longitudinal waves

- http://einstein.byu.edu/~masong/HTMstuff/WaveTrans.html



- http://paws.kettering.edu/~drussell/Demos/waves/wavemotion.html

Try these animations at home



Describing a Wave

- **Wavelength** is the distance from any point on the wave to the next similar point.
- **Frequency** is the number of vibrations made by any point per second (1 vib/sec = 1 Hertz).
- **Amplitude** is the maximum height or depth of the wave measured from the midpoint.
- **Wavespeed** is the speed at which the disturbance travels through the medium.

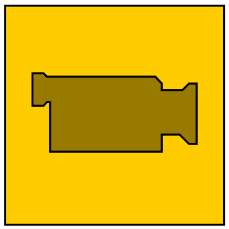
Textbook Figure 9.5

The Parts of a Wave

Explanations and illustrations of the parts of a wave

- http://id.mind.net/~zona/mstm/physics/waves/partsOfAWave/waveParts.htm

Try this animation at home



Wave Interference

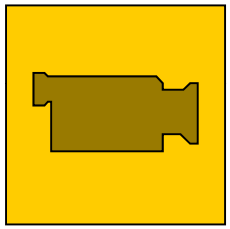
- When two waves travelling in opposite directions meet, they **interfere**.
- This means that as they pass through each other they create a combined wave, whose shape is the sum of the two waves.
- After passing through each other, the two waves continue undisturbed.

Textbook Figure 9.8

Constructive and Destructive Interference

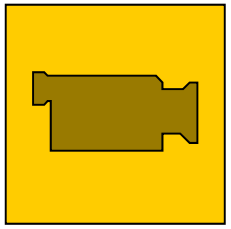
Constructive interference of two waves

- When two waves of the same orientation meet, they interfere by reinforcing each other.
- http://www2.biglobe.ne.jp/~norimari/science/JavaEd/e-wave2.html



Destructive interference of two waves

- When two waves of the opposite orientation meet, they interfere by cancelling each other.
- http://www2.biglobe.ne.jp/~norimari/science/JavaEd/e-wave3.html

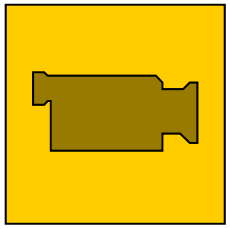


More Interference Animations

Several examples and explanations of wave interference

- http://id.mind.net/~zona/mstm/physics/waves/interference/intrfrnc.html

Review these examples at home



Wave Interference in 2 Dimensions

Here are two waves in water.

What will their interference pattern look like?

Textbook Figure 9.11

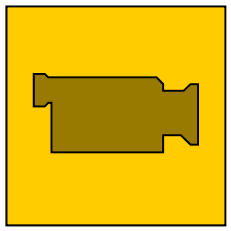
Textbook Figure 9.12

2-D Wave Interference Patterns

Two source interference pattern

- http://id.mind.net/~zona/mstm/physics/waves/interference/twoSource/TwoSourceInterference1.html

Try this animation at home



The figure shows two sets of waves, created by sources A and B. The black lines represent wave crests from A, and the gray lines represent wave crests from B. Suppose that individual wave crests from either source A or source B alone are 3 mm above the level of the undisturbed water. Then the displacement of the water [above or below the level of the undisturbed water] at point "x" is:

(A) +6 mm (B) +3 mm (C) 0 mm

(D) -3 mm (E) -6 mm