Notes - Princeton U., Fri., Feb. 3, 2017 by John B. Johnston

website: https//www.tinyurl.com/WS-Johnston

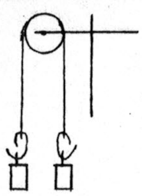
Topic - a brief history of "g" (9.8 m/sec^2 ?)

1. free-fall: a sheet of paper vs a golf ball

   Aristotle in 364 BC
   Galileo in 1584 AD
   Newton in 1662 AD
   All 20 yrs. old.

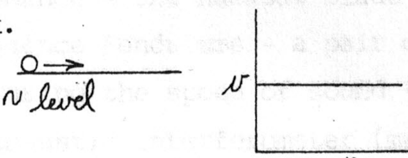
   $$Wt = m\,g \quad \text{or} \quad g = \frac{Wt}{m} = \frac{2Wt}{2m}$$

2. velocity and acceleration: a nice study of kinematics - constant vel. , const. accel., and nonuniform accel. by sight and sound

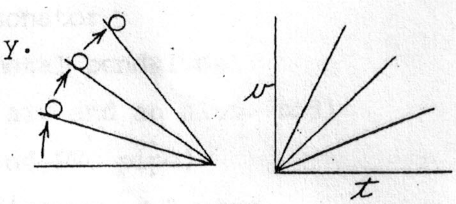


   (a) 8 ft. long alum. track and a steel ball
   (b) a nearly frictionless pulley wheel, nylon thread, 50 gm masses, paper clips
   (c) chalkboard graphs

x.



y.



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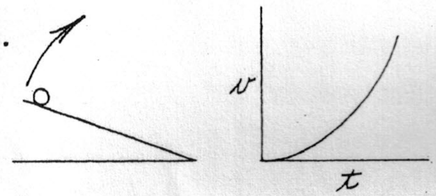
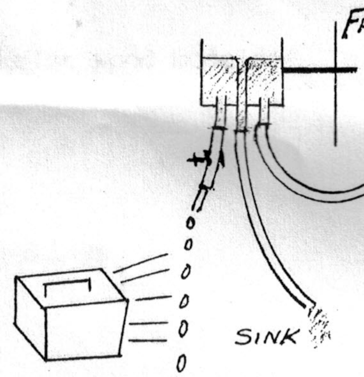


3. free-fall of water droplets: a beautiful "g" pattern; constant level tank, hoses, medicine dropper, C-hose clamp, strobe light



4. "Free-fall bodies - the hinged board with cup"

5. "The "g" stick and different values of "g"

6. "The rotator (elect. drill) and accessories", Part (c) - variable g via planetary deformation (167 lb. at NP vs 166 lb. at Eq.)

7. "The inverse square relationship (3-D model)" - variable g due to changes in gravitational field strength because of distance from the center of gravity

   $$F = G\frac{m\,m'}{r^2} \propto \frac{1}{r^2}$$

   a bathroom scale: 160 lb. at altitude 4,000 mi. is 40 lb.
   at 8,000 mi. up, ∞18 lb.
   at 12,000 mi. up, 10 lb. etc.

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The Darth Vader Disc (center of mass)

The inverse square relationship (3-D model)

The "g" Stick (free-fall and different values of "g")

Free falling bodies - the hinged board with cup

Vectors - forces and the inclined plane

Vectors - velocities and river crossings

The sail cart - force vectors & sailing

The rotator (electric drill) and accessories

Tension in a pendulum (using a spring scale)

2-D Motion - a teaching model (stick with hanging spheres)

2-D Motion - centripetal force (using Johnston's "Singapore Sling")

Horsepower - a brief essay

Resonance - the hacksaw blade resonator

Resonance Pendulums - a pair of metal pendulums

Measuring the speed of sound (in air and an alum. rod)

An acoustic interferometer (made of PVC pipe)

Wire waves I - a jig for making wire waves & uses

Wire waves II - a second jig for making wire waves & uses

Demonstrations: the eye of a needle and Poisson's spot - actual size wood models

Poisson's spot - a steel ball bearing on a magnetised needle

A wood model of a polaroid filter (and explanation)

The 3 3/8" x ... acrylic container (Prism) - a triangular trough

Dispersion via diffraction & interference - using diffraction gratings

The "To-Infinity" mirror system - reflection via flat mirrors

Light - reflection via the flat-mirror periscope

Light and a real image via reflection - the concave mirror

Light and a real image via refraction - the convex lens

The 5" x ... Acrylic Container - flat-sided box (The "blue beer" demo)

Reflection - a front surface, parabolic, water mirror - using a record player

Total internal reflection in a stream of water

Atmospheric refraction - using "sugared" water

The rainbow - a one-drop rainbow and explanation

Dispersion - spectra via reflection and interference (in thin soap film)

A "spectra" comparator - elementary spectroscopy

All of these demonstration write-ups are on the internet at a Union College (Schenectady) website: (OVER)

http://minerva.union.edu/vineyarm/john_johnston/john_johnston.html

More will be added in the future.

The hand-held Tesla coil - uses
The "green" comparator - using a 120 VAC (home) powerline meter
Wire Loop I - a jig for making wire "coil" loops as teaching models
Wire Loop II - a jig for making wire "generator" loops as teaching models
The Ring Flinger - a 120 VAC electromagnet as a transformer
The blue sky and ... - Rayleigh scattering in a watertank
Sunspots or relative temps. and colors on the sun's surface
Northern lights or the aurora borealis
The Snowflake - water's polarity and surface tension
Standing Waves in the Hydrogen Atom - a cardboard model
Electromagnetic induction
Self-inductance and mutual inductance
The monkey and the hunter
Static electricity (Braun 'scope)
Wimshurst machine
The vortex box
Friction
Electricity - Coulomb's Law
The Millikan Experiment
The Gas Laws - a teaching model
Absolute zero
The water molecule - a teaching model
!! A new link to the Union College website is https//www.tinyurl.com/WS-Johnston
The flame tube
The Van de Graaff generator
Magnetism and the acrylic tray
Demonstrations on the OHP
Crystal packing

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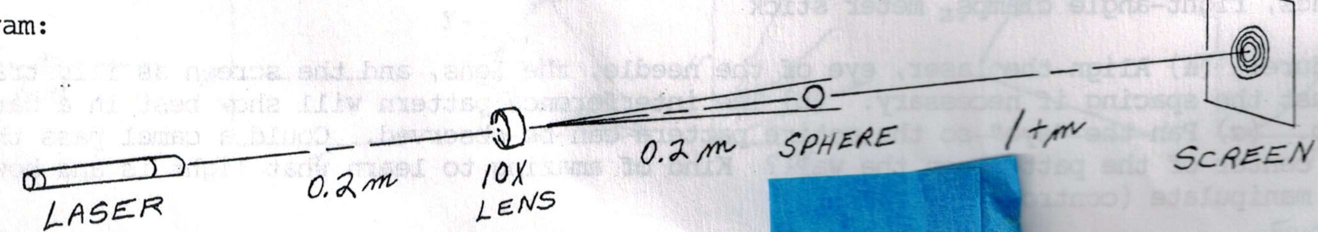
Poisson's spot - long considered one of the great experiments (demonstrations) on the topic of light. It is easily performed today via the use of the laser and some simple materials. But first, a little history to illuminate its importance in the development of our knowledge about the nature of light.

1672 - Newton's corpuscular (particles of matter) theory of light.
1678 - Huygens' wave theory of light (principle).
1803 - Young's double slit experiment (interference pattern) predicted by Huygens' principle.
1819 - Poisson (particle supporter) vs Fresnel (wave supporter). Fresnel's wave (diffraction) equations were solved by Poisson who considered the result reached absurd. It predicted that a bright spot due to diffraction (and interference) would occur behind the center of a small, round, solid object (sphere?) instead of a shadow. Arago (particle supporter) set up the experiment and discovered the spot. Fresnel's reputation and the wave theory were secure. Rarely mentioned is the beautiful interference pattern of concentric circles which adds further credence to the wave nature of light. The pattern is simply an extension of Young's experiment.

Diagram:

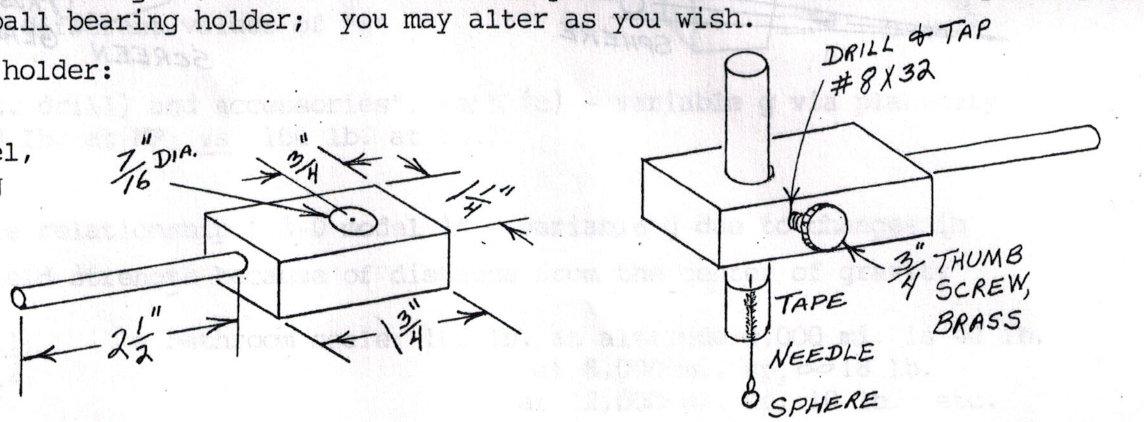


Materials: laser pointer (red or green), 10 x lens (microscope ocular, simple magnifier), ball bearing, steel (3/32"), screen, white (posterboard, classroom wall), ring stands, right-angle clamps, meter stick

A simple way to "suspend" a small, steel ball bearing is on the tip of a steel needle taped onto the end of a small bar magnet; the needle is mostly unobstrusive. Below is my design for a simple, wooden ball bearing holder; you may alter as you wish.

Plan for ball bearing holder:

3/4" pine
3/8" dia. dowel,
3 1/8" long

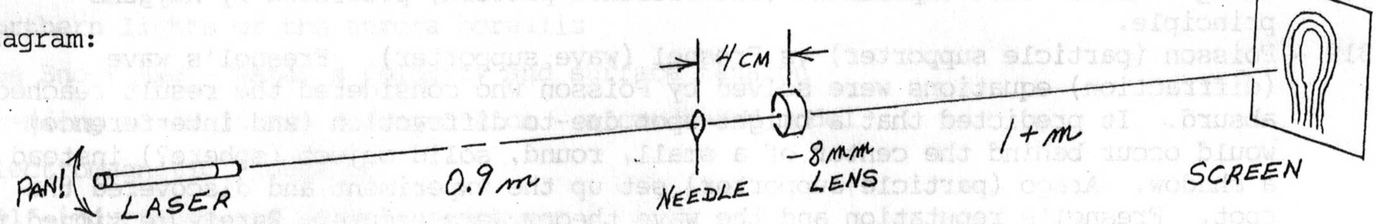


Assembly of bearing holder: (a) Cut out pine block and drill the three necessary holes: 3/8" dia., 5/8" deep for dowel; 7/16" dia. through for 3/8" dia. magnet; and #29 drill bit through for #8 brass thumb screw. (b) Cut the dowel, sand ends, add glue, and tap it into the block with a hammer. (c) Carefully tap the #8 thumb screw hole; add wax or soap to the thumb screw and carefully twist it into the block. (d) Tape a small needle to the end of the magnet with the eye extended about ½". Insert the magnet into the wooden holder and tighten the thumb screw until snug. Don't over-tighten and strip the wooden threads. Fasten the holder to a ring stand with a right-angle clamp. Add the bearing. A small, steel bearing of a different size may be used; experiment. The 10 x lens acts as a beam spreader.

Procedure: (a) Align the laser, lens, bearing, and screen as illustrated in the diagram; adjust the spacing (0.2 m) if necessary. (b) The spot and pattern will show best in a darkened room. Have the students get up close for a better look; they can now see what Arago saw for the first time in 1819. Neat!

Addendum: The eye of a needle - another classic demonstration, closely related to Poisson's spot, is one that can be projected in a large pattern on a classroom wall. The laser's light diffracts around the needle's eye, inside and out, and establishes a tiny interference pattern that is expanded by the diverging lens onto a large screen or wall. The demo is another important verification of the wave nature of light.

Diagram:



Materials: laser pointer, very small needle, -8 mm concave lens, screen, white (wall?), ring stands, right-angle clamps, meter stick

Procedure: (a) Align the laser, eye of the needle, the lens, and the screen as illustrated; adjust the spacing if necessary. (b) The interference pattern will show best in a darkened room. (c) Pan the "eye" so the entire pattern can be observed. Could a camel pass through the center of the pattern on the wall? Kind of amazing to learn what light is and how we can manipulate (control) it.

Addendum: An alternative screen for both demos. If a darkened room is not possible, try a pane of frosted window glass as a screen and view it from behind. It is safe, and the patterns are clearly visible. I mounted the glass (9½" x 11") in a simple frame so I could easily attach it to a ring stand.

Diagram: