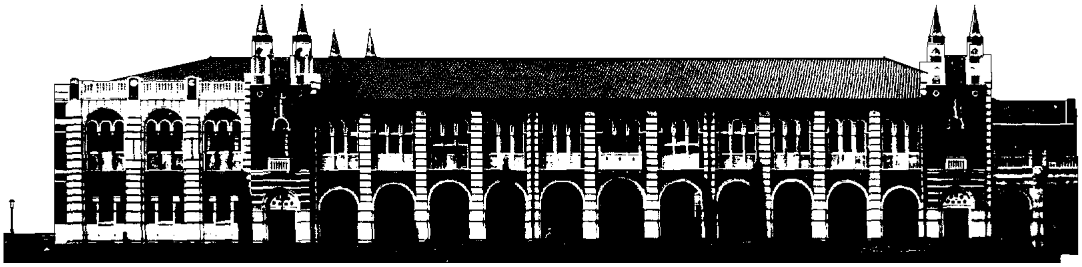

PHYSICS 101

DEMONSTRATIONS

RICE

October 3, 1996

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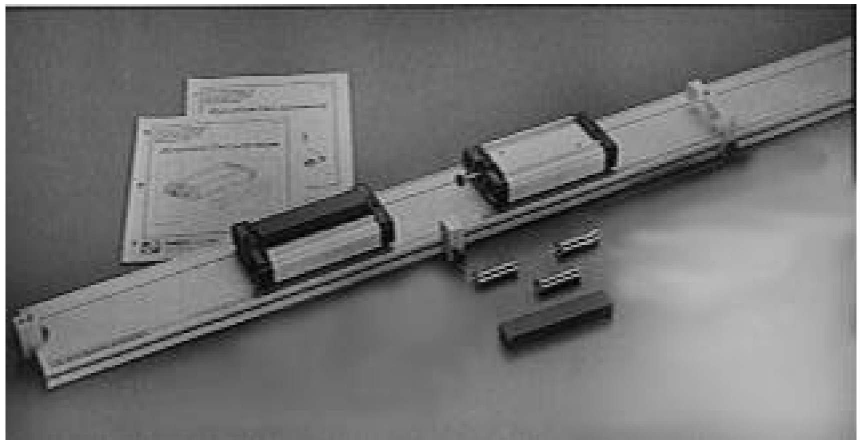
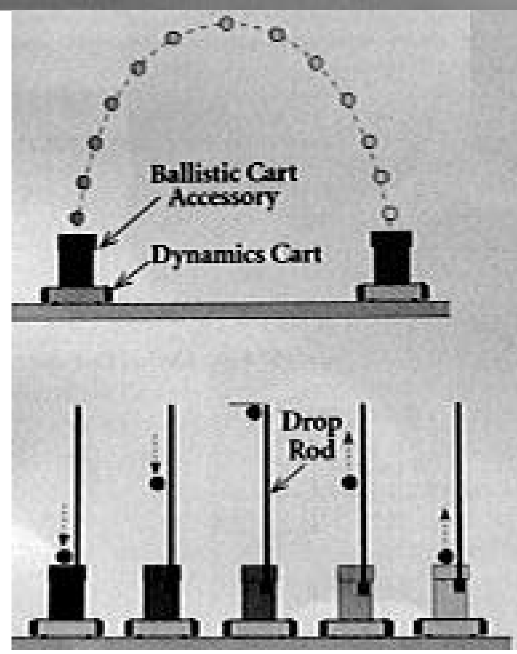
PHYSICS 101 DEMONSTRATIONS.

I. RECENTLY ACQUIRED DEMO EQUIPMENT:

A) The PASCO Dynamic Cart System that can be used instead of the air track for many demonstrations.



B) Using the PASCO Dynamic Cart System with the Ballistic Cart Accessories.



PHYSICS 101 DEMONSTRATIONS.

1. MEASUREMENTS and STANDARDS

a) **Mass**: Polished brass kilogram from scale set

b) **Length**: Platinum standard meter (calibrated by NBS)

Standard Meter

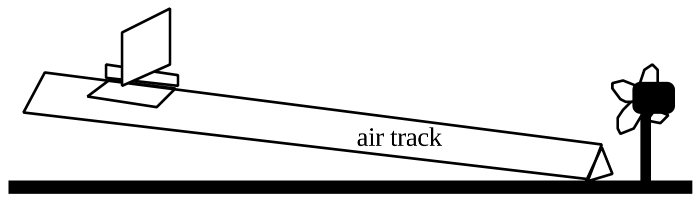
c) **Funny**: "Standard Foot" (wooden model of human foot)

Copy of Standard Foot

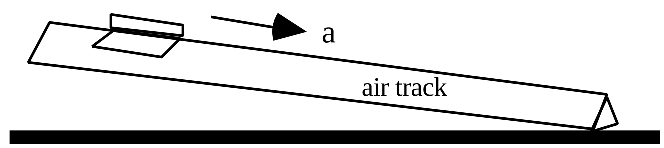
d) **Time**: Radio receiver set up to receive WWV time standard

2. KINEMATICS.

(a) **Uniform Velocity**: Air track. Track slightly tilted with rider + sail. Fan on sail produces slow motion so that one can get s vs. t with stop watch. Can plot on overhead to show x(t), v(t) = slope.
* Use a computer, the **Universal Lab Interface** and the sonar head to show a plot of uniform velocity.



b) **Uniform Acceleration**: Tilted air track. Do Galileo experiment to show s t^2 by releasing rider from rest.
* Use a computer, the **Universal Lab Interface** and the sonar head to show a plot of uniform acceleration.
* Use wood planks to build rising and falling tracks for balls to be rolled on.

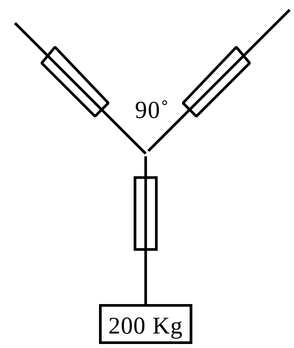


Mount camera above to show an overhead view of the rolling ball.

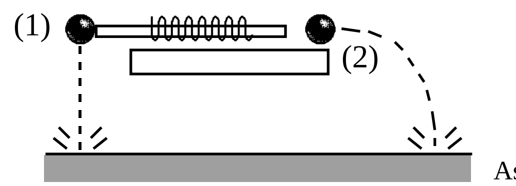
c) **Time Intervals of Fall**: Falling beads ("Galileo's beads"). String of beads spaced so that when hung from ceiling and released, they strike ground at equal time intervals. (This requires bead separation to increase as the odd integer, 1', 4', 9' and 16' above resonant board.)

d) **Vectors**: We have some wooden "arrows" That can be used to show graphical addition and subtraction.

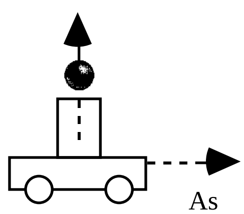
3 springs with 200Kg weight. Cut the sttring to the weight and watch the bottom scale rise vertically.
Also can be a demo for second law.



e) **Simultaneous Fall**: Projectiles: one fired horizontally, one dropped.
When spring is released, ball (1) drops vertically when ball (2) is fired horizontally. Balls hit ground at same time. Shows that horizontal motion does not affect vertical motion.

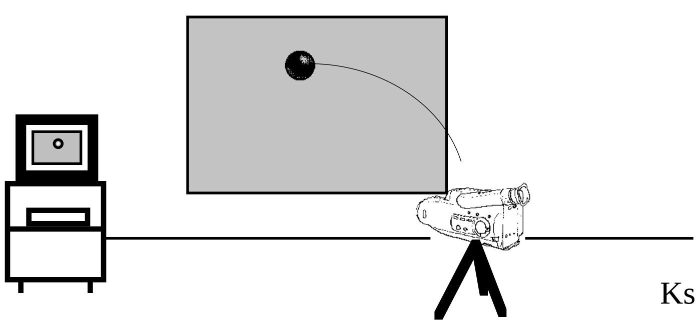


f) **Horizontal Motion**: "Skate board"



Car fires ball vertically while moving forward at constant velocity. Ball falls back into barrel. (Compare with skate board rider who leaps over car while board goes under car.)

g) **Projectile Motion**:



A ball moves along parabolic path. Take video recording of orbit against 'BLUE tarpaulin with grid' and playback one frame at a time on TV.

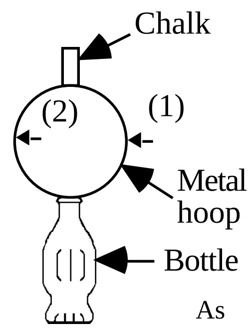
h) **Vertical Motion**: Can and gun, or "the monkey on the pole". Can suspended from pole by electromagnet. Gun at other end of lecture table is "bore sighted" on can. When gun is fired, can is released. Projectile hits can irrespective of velocity of projectile.
NOTE: crimp hose so no air can pass. Then blow hard and release crimp in hose. Also make sure the projectile is all the way to the bottom of the firing tube.

i) **Circular Motion**: see Bowling Ball on page 8.

NEWTON'S LAWS

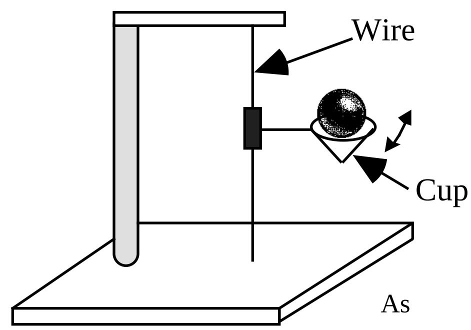
1. **First Law - Inertia**:

a) Chalk-in-bottle.



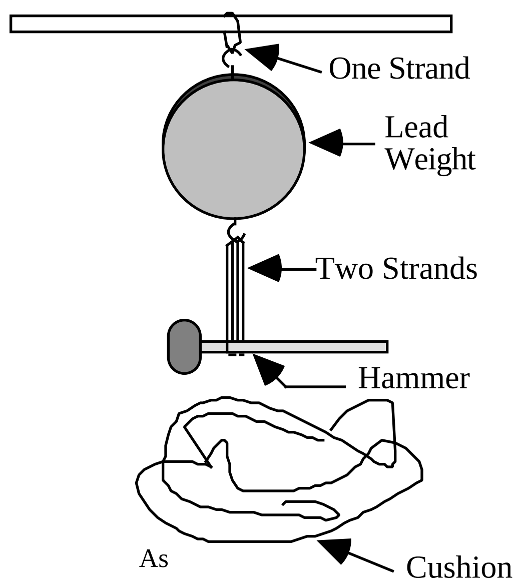
Tell class you will hit hoop so it will allow chalk to drop into bottle. Pretend to hit hoop at (1), but **actually** hit it at (2). Hoop will fly to left and chalk will drop into bottle. (If hoop is hit at (1), chalk will fly up and miss the bottle.)

b) Inertial "balance"



Cup is attached to torsion wire. If displaced to one side, it oscillates rapidly when cup is empty, much more slowly when a steel ball is in the cup. The ball "resists changes in motion."

c) Inertia Block:



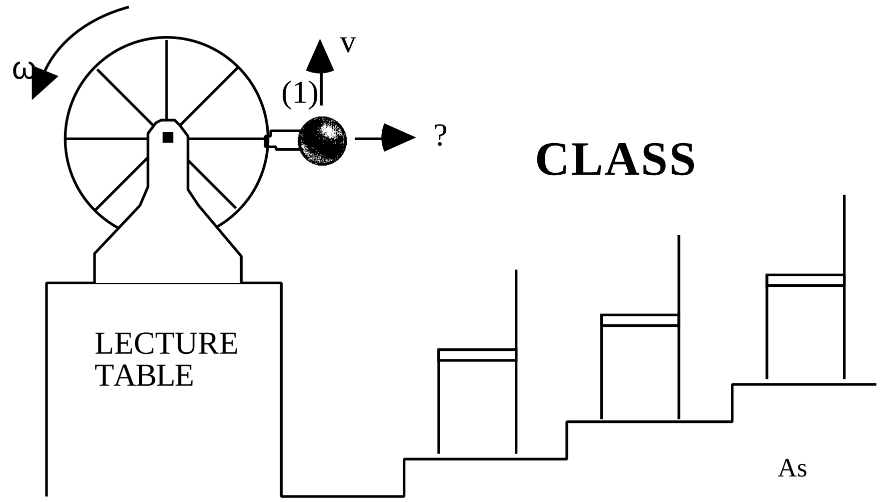
Mass with strings. A large lead weight is suspended from cross-bar by one strand of string. Two strands are attached at the bottom and around a hammer.

If hammer is pushed down **slowly**, tension in top string is always **much** larger than in bottom string, and it will break first. But, if hammer is lifted and struck down sharply against bottom strings they will break, leaving top string intact.

[Build a horizontal version, see M-16.]

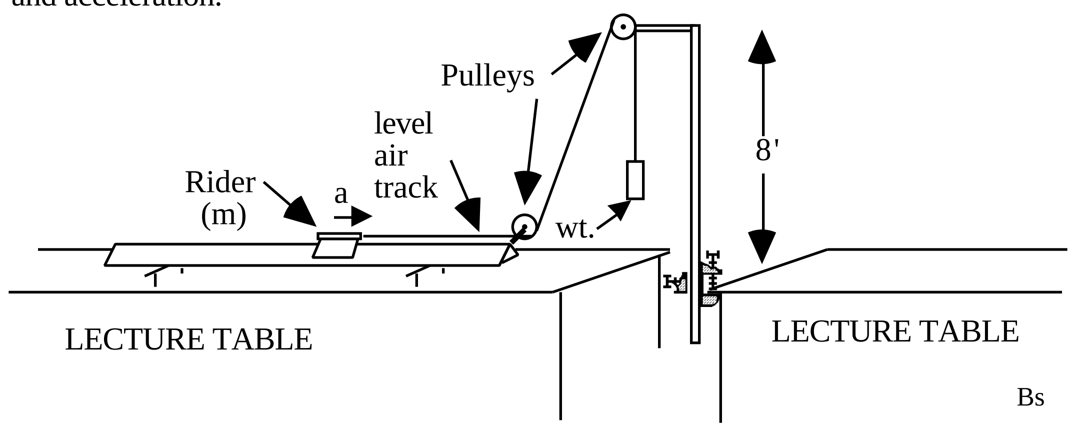
d) Ball-on-wheel

Ball is attached to rim of wheel with light thread. Wheel (and ball) are set into rotation at high speed. Tell class you will hold razor blade at (1) to cut thread. Will ball "be thrown out" into class? **No**. It obeys 1st Law and flies straight up.



2. **Second Law**:

Several experiments can be done with the air track to show relation between force, mass and acceleration.

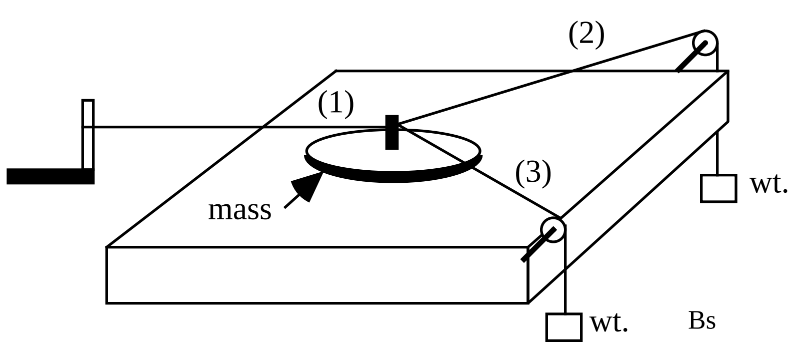


a) Apply various small weights to thread-pulley system. Show that acceleration = constant.

b) Vary mass of rider. Show that a decreases as m increases.

c) Air table.

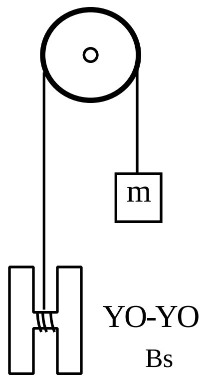
Mass is supported in equilibrium by three threads. Resultant force is due to (2) and (3) is balanced by (1). If thread (1) is cut, motion will be along the direction of thread (1), showing that **a** is in the direction of **F** result.



Mount camera on sky hook to view air table from above.

3. **Third Law**:

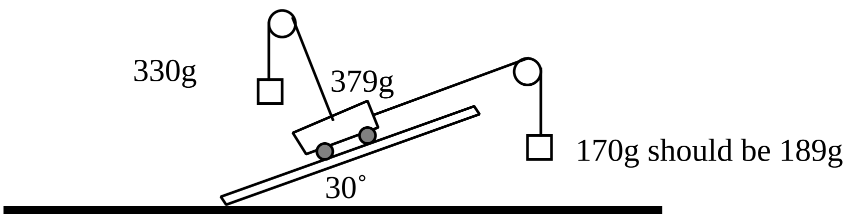
Monkey and Bananas



Yo-yo and mass m of equal weight are suspended by thread over pulley. If yo-yo is wound up and both released from rest, yo-yo and m move up and down together (almost!).

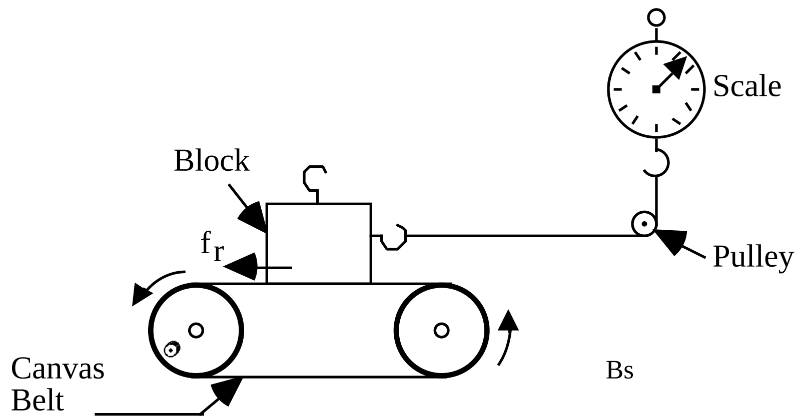
Atwood Machine see page 17.

FREE BODY DIAGRAM:



FORCES - FRICTION:

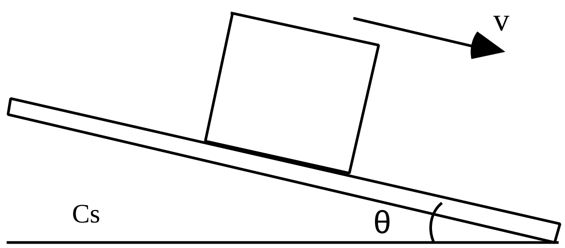
a) **Bryan Friction Machine**



When canvas belt is driven, it slides against the block that rests on it. You can show:

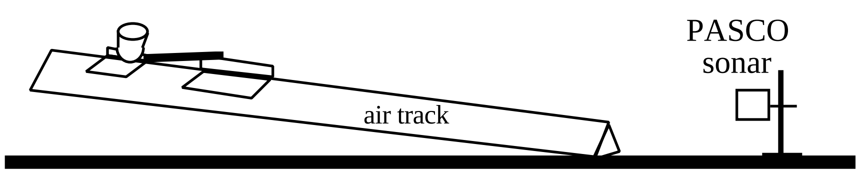
1) friction roughly independent of velocity
2) friction independent of area of contact (stand block on different faces)
3) friction α force pressing surfaces together (normal force) [add load to block]

b) **Inclined Plane**: Wood block on tilted board

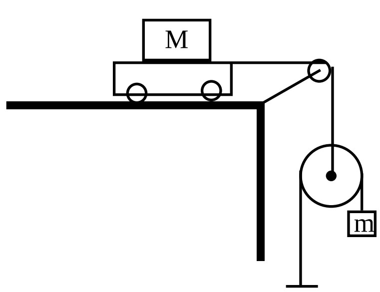


Show: $\mu_S > \mu_K$ and determine

μ_K , μ_S from tan θ.



Friction brake attached to rider. Put weights in cup to increase load on brake.



Pulley and cart setup, re. Dunning 9/28/93

Break Board with hand. Use a very dry board, there are some pieces in the basment, and hit along the grain. Dunning did this 9/23/93.

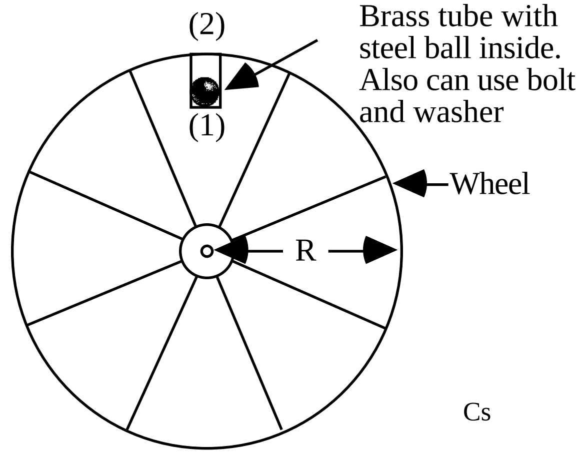
CIRCULAR MOTION:

a) Bike wheel and "clicker"

If wheel is turned slowly, ball will move from one end of tube to the other as the wheel turns. (It will be at (1) at top, (2) at bottom.) If rotational speed is increased, "clicking" will eventually stop when the ball stays always at (2). Critical speed for this is when $\frac{v_T^2}{R} = g$. (A good measurement of g can be obtained by measuring the rotation rate at which the "clicking" just stops.)

$V_T = \frac{2\pi R}{t}$ t=time of 1 rev.

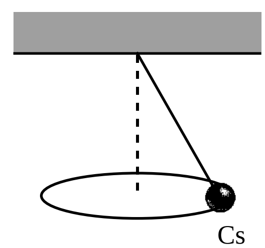
R=radius of steel balls path.



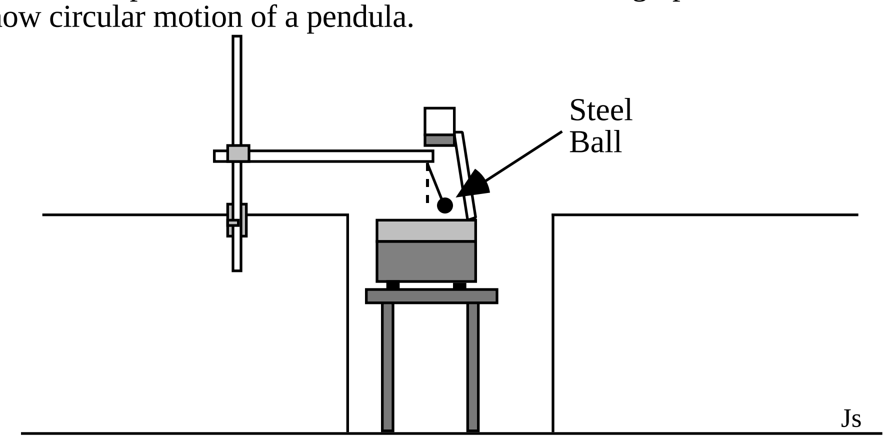
b) Conical pendula

1) You can set up a bowling ball attached to rope fixed to ceiling:

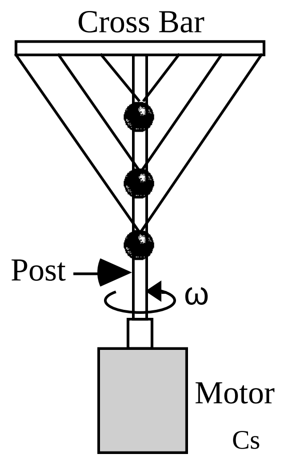
Ball can be set into conical motion and forces analyzed.



2) You can suspend a steel ball over a circle on a viewgraph, on an overhead projector; to show circular motion of a pendula.



3) **Three pendula on a stick**:

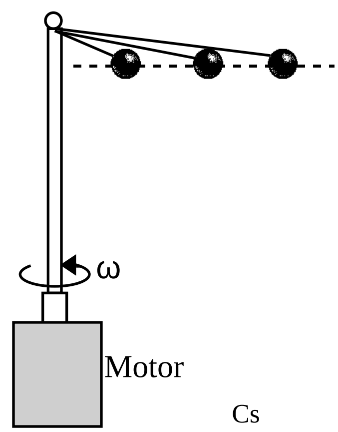


Balls are suspended from cross bar with bifilar suspension. If stick is rotated, balls will move in horizontal circles.

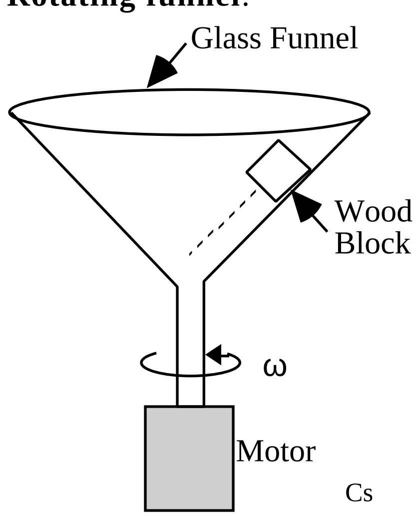
It is not hard to show that they will all move in the same plane.

Use an overhead projector to show shadow of balls on wall.

Or clamp a meter stick or rod horizontally to help sight the balls.



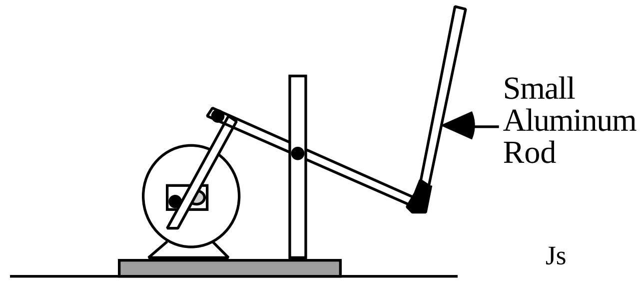
4) **Rotating funnel**:



A small wood block will slide down the side of a funnel when $\omega = 0$. If ω is large, block will be thrown out of the funnel. For a certain range of ω's, friction is sufficient to hold block in place on the side of the funnel. (It is instructive to work this out as an example.)

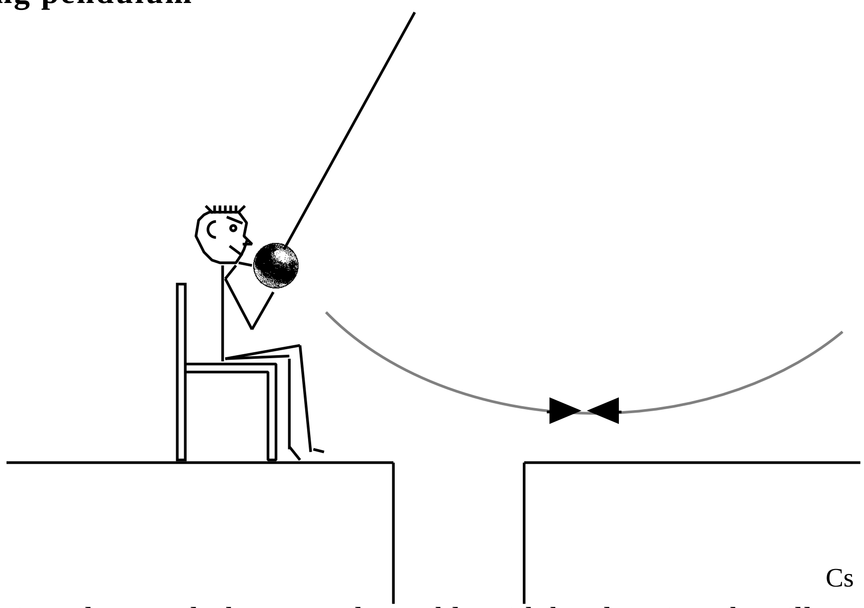
c) **Upside Down Pendulum**:

A variable speed motor yields vertical undulatory motion by means of a crankshaft and horizontal shaft with stable guides. A small aluminum rod is attached to the pivot at the free end of the horizontal shaft. Gently hold the rod vertically, then increase the frequency of oscillation. At a respectably high frequency, the rod will oscillate stably in this inverted position. (M-67, MA-1)



WORK and ENERGY

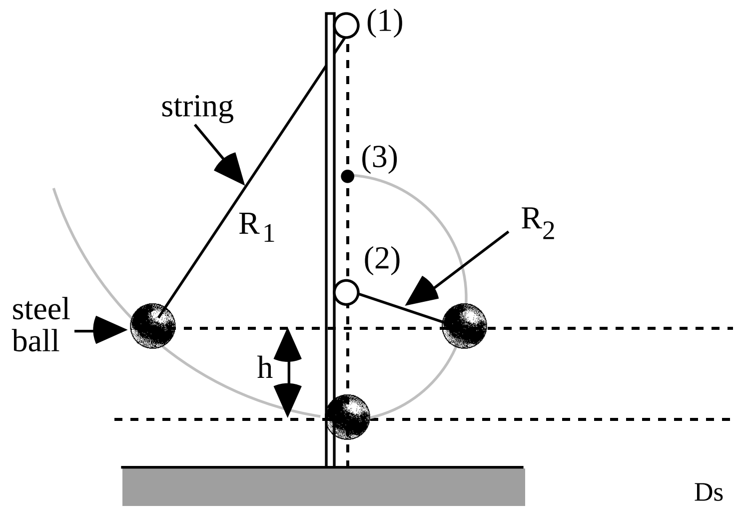
1. Swinging pendulum



Sit in chair on lecture desk, or stand on table with head against the pillar. Hold bowling ball pendulum to chin. Let go. Ball returns, but doesn't hit chin. (Don't push ball when you release it!)

2. Galileo pendulum

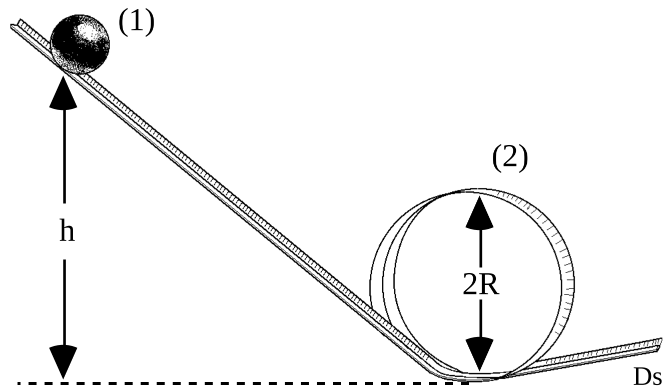
Pendulum is suspended from support rod (1) and released. When string hits rod (2), it swings in circle of smaller radius. If energy is conserved, it will return to original height h. This is also the way to do "loop the loop" demonstration. If release point is high enough, ball will go all the way to (3) without the string going slack. (see next item). This requires $h = \frac{5}{2} R_2$.



NEEDS BLACK STRING!

3. "**Loop-the-loop**"

Release ball from point (1). If h is large enough ($h \geq \frac{5}{2}R$) ball will reach point (2) without losing contact with track. (Actually, this is the case for sliding with no friction. With a rolling ball, some energy goes into rotational motion, so $h > \frac{5}{2}R$ is required.)



4. "**Student Power**"

Ask a student to run at maximum speed from amphitheater desks up the center aisle stairs to the top. Time ascent with a stop watch, starting watch when student reaches lowest step. Change in height is Δh = 15.3 feet. Power output can be calculated from Δt, Δh and student's weight (~ 1HP).

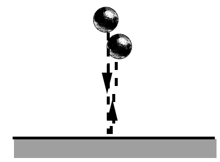
5. **Work = ΔKE**

Mass m slides distance x down the tilted air track. It passes through timer at bottom that measures v. Show that $x = \Delta v^2$.

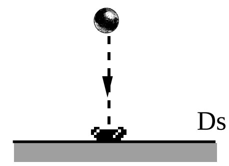
COLLISIONS and CONSERVATION of MOMENTUM

1. **Elastic vs. inelastic collisions**.

Use two balls to bounce on lecture table:



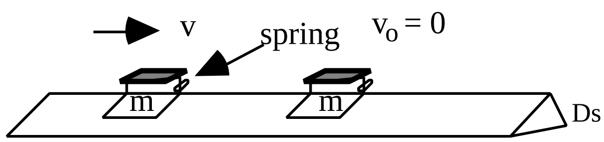
a) superball: nearly a perfect bounce. KE ~ constant.



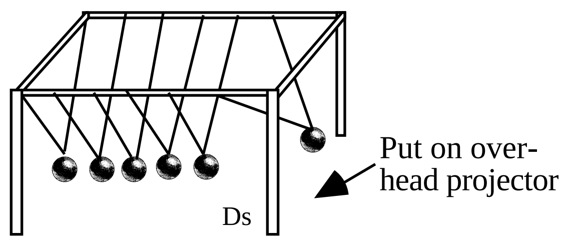
b) Ball of "Q" wax: perfectly inelastic. All KE is lost.

2. **Elastic collisions**

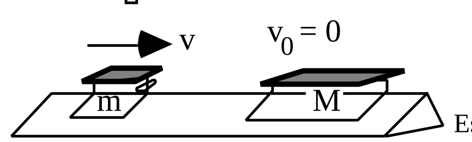
a) Equal masses } exchange of velocity. Use air track.



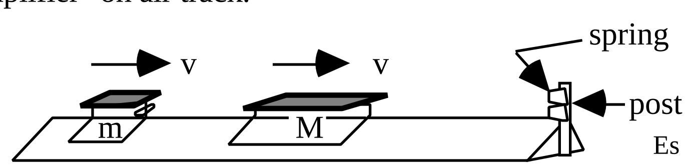
b) Collision balls:
Same as (a), with a line of balls that collide one-at-a-time.



c) Unequal masses } magnitude of relative velocity is constant. Use air track. Follow each rider with finger } rate of approach ~ rate of separation.



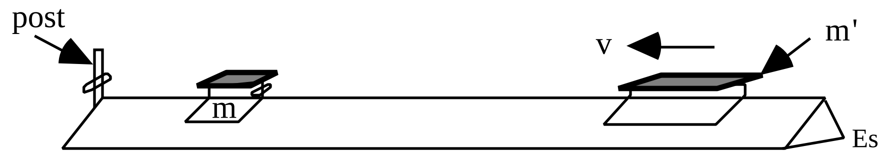
d) Large M hits small m initially at rest. Use air track. For M >> m, $v_m \rightarrow 2v_M$. Can use this for a "velocity amplifier" on air track.



Small m and large M approach end of air track with velocity v. M hits post first, and its velocity is reversed. It then collides with m. Their relative velocity is 2v. If M >> m, v_M is not much changed. So, since relative velocity after collisions is still 2v, v_m is reversed and has the value 3v. Could use more masses, m, M, M', with M' >> M >>> m and get $v_m = 5v$, and etc.

e) Two 'SuperBalls': Drop so the velocity of the top (smaller ball) is amplified. This does take some practice, see G. Mutchler for coaching.

f) The "Wayward Private." A parable involving elastic collisions:



"**Private** " m has gone to a bar at left end of track, and is drunk. His company commander wants to get him back, and sends **another private** to do the job: m' = m.

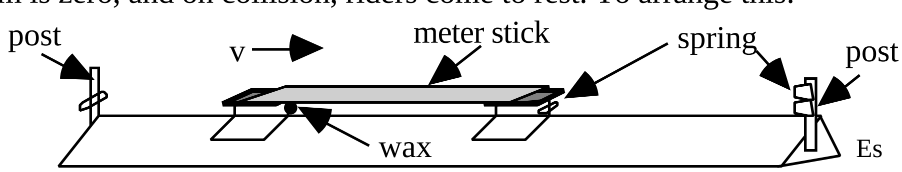
1) m' goes down the track and exchanges v with m. m hits post and v is reversed. m hits m' and exchanges v . Net result is that m stays at post and m' returns.
2) Commander now sends **Lt**. down (m' = 3m). Collisions are now more complicated, but net result is that m stays at post and m' returns without m.
3) Commander now wises up and sends the **sergeant** down (m' = 2m). After several collisions, m follows m' back to base.

-- END OF STORY --

3. **Inelastic Collisions**

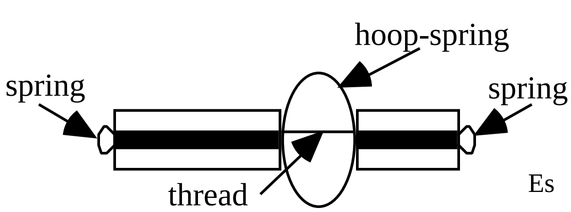
Use the air track plus riders for these experiments. To make collisions inelastic, remove springs and replace with pea-size ball of tacky-wax. NOTE: *use tape to prevent the wax from sticking to the riders.*

a) Equal masses. Most dramatic demonstration is to have velocities equal and opposite. Total momentum is zero, and on collision, riders come to rest. To arrange this:



A Meter stick rests on two riders so they move together. Impart a velocity v to system, then lift meter stick straight up so as not to change velocities. Right-hand rider will hit post, and its velocity will be reversed. When it collides with left-hand mass, riders will come to rest.

b) Unequal masses. Again, it is best to arrange velocities so that total momentum is zero. To do this, use the "**BAKER PROJECTOR**". Top view of riders on air track:



Use match or scissors to break thread.

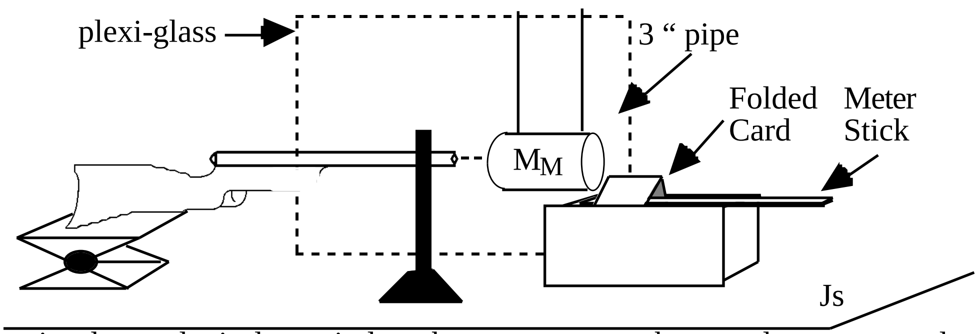
A flexible hoop is compressed and tied with a thread. The loop is mounted between two riders. (It can be balanced on two small pieces of match stick held to riders by tacky-wax.) When thread is burned, riders will be projected with $m\mathbf{v}_m + m\mathbf{v}_M = 0$. They will strike posts at ends of track and velocities will be reversed. They will collide inelastically (if ball of tacky-wax is properly located) and come to rest.

4. **Ballistics experiment**.

A good measurement of the velocity of a .22 bullet can be made with a "Ballistic Pendulum".

To do this experiment suspend the 3" pipe with wood inside from the sky-hook. And measure the distance the pipe + .22 long rifle bullet moves after firing. Use a folded 3X5 card, guided by a meter stick, to measure maximum displacement, ~ 18 cm or 7 inches, with the ~4920 gram pipe. Be sure to weigh the pipe before and after each shot.
It is **792 cm or 26 feet 10 1/8 inches** from the bench top to the top of the 'Sky Hook' mount. The center of gravity for the block is approximately 9 inches above the bench top, so L equals 26 feet 1 inches or 770 centimeters.
(For .22 long rifle; m_b = 2.59 grams and v_b ~ 380 m/sec or 1250 ft/sec.)
(For .22 shorts; m_b = 1.93 grams and v_b ~ 280 m/sec or 900 ft/sec.)

$g=9.8\ m/sec^2$ $\qquad v_M=\sqrt{2hg}$ $\qquad v_b=\dfrac{(M_b + M_M)}{M_b}\ v_M$

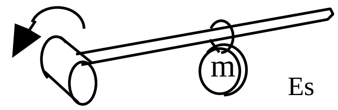


(Note: There is a large plexi-glass window that mounts near the muzzle to protect class from any flying fragments.)
Also, 1 grain = 0.06479891 gram; so a 40 grain bullet equals 2.59 grams.

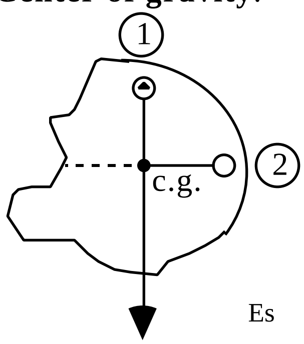
ROTATIONAL MOTION

1. **Torque weight-lifter**.

A plastic handle is attached to a metal rod ~ 1 meter long. The handle can be gripped and a mass m lifted off the table by rotating the handle. It is very difficult to lift the weight (m ~ 2 kg) when it is at the end of the rod., but easy when it is close to the handle. Most students cannot do the first case, but <u>you</u> can, with a little practice and <u>lots</u> of chalk dust on your hands. (The students hands will be sweaty!)

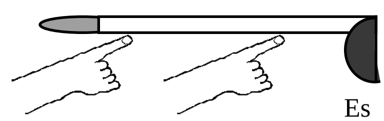


2. **Center of gravity**.



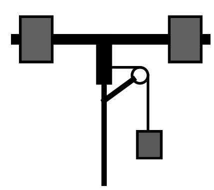
a) Center of gravity of planar object (a board) can be determined with a pivot and a plumb-bob. Suspend from holes (1) and (2) and draw a line on board with chalk along plumb line, Inter-section gives center of gravity.

b) Center of gravity of irregular linear object (e. g. a golf club or pool cue). Balance the object on your fingers. If you move fingers slowly together, both fingers will meet at center of gravity. This is due to the fact that the normal force is largest on the finger closest to center of gravity. Thus friction force is larger, and finger <u>furthest</u> from center of gravity will move!

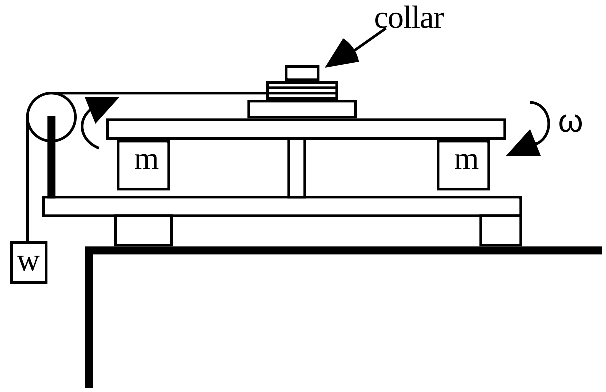


3. **"Whirly-gig."**

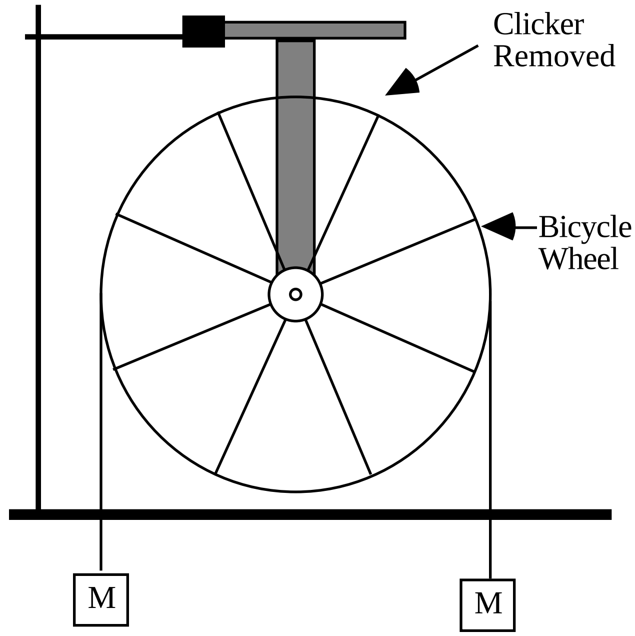
old - <u>Single radius collar</u>



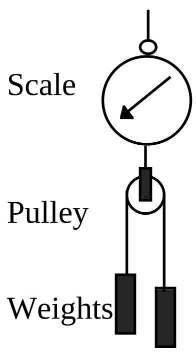
new - Two masses m are attached to a bar and <u>triple radius collar</u> that rotates around, a vertical axis. A string is wound around the collar, which passes over a pulley to weight w. A constant torque can thus be applied to the system, which can be varied by changing w. The moment of inertia can be changed by adjusting distance of m's from axis. A quantitative study can be made of $\tau = I\alpha$.



Bicycle wheel-- **Atwood Machine**.

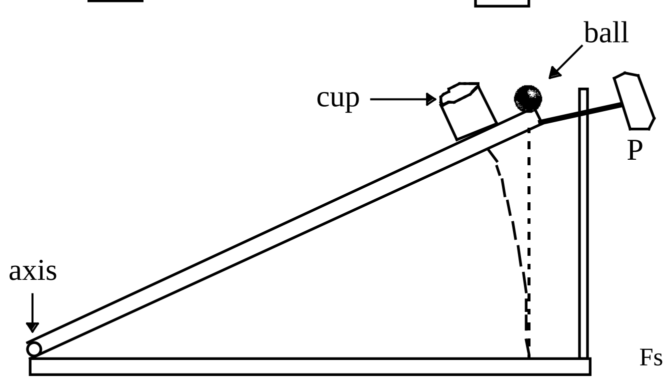


Second Law/Atwood's machine.



4. **Ball-in-the-cup**

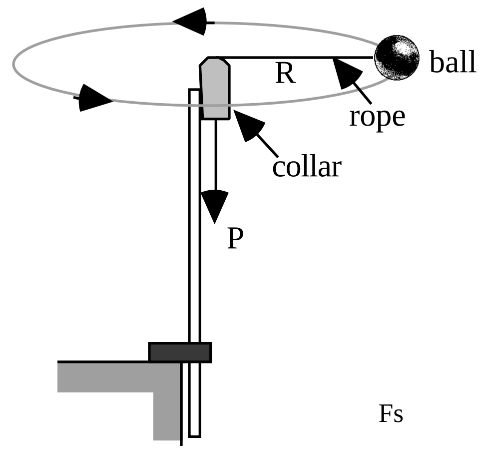
A ball is placed on the end of a stick free to rotate about a fixed axis. A cup is mounted on the stick such that after the stick reached the horizontal position, the cup is under the initial location of the ball. When the pin P is pulled, the stick falls, and the ball appears to "jump" into the cup. Actually the acceleration of the <u>end</u> of the stick is <u>greater</u> than g, so the cup really falls faster and moves under the ball.
(There is also a set of weights that can be clamped to the end of the stick, which <u>slows down</u> the stick, so that the ball misses the cup.)



5. **Conservation of angular momentum**.

a) Ball-on-rope.

A ball is attached to a rope that passes through a fixed collar. The ball is set into rotation in a horizontal circle. By increasing P, the rope length R can be shortened, and the angular velocity of the ball increased. Or by decreasing P, R can be increased and ω reduced.



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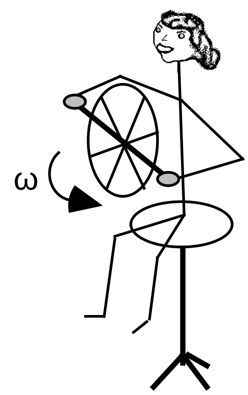
b) Stool and bike wheel.

Sit on stool holding bike wheel. If wheel is spinning, you can set yourself into rotation by changing direction of axis of wheel (up or down). Or, with wheel at rest, hold axis vertical and set into rotation. You rotate in opposite direction.



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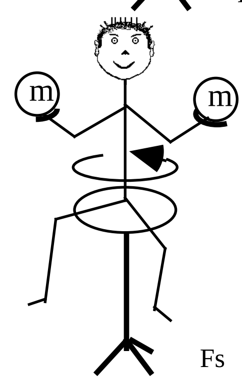
c) Stool and weights.

Sit on stool with 5 kg masses in hands. Set yourself into rotation with arms extended. If masses are now brought close to axis, ω increases greatly.



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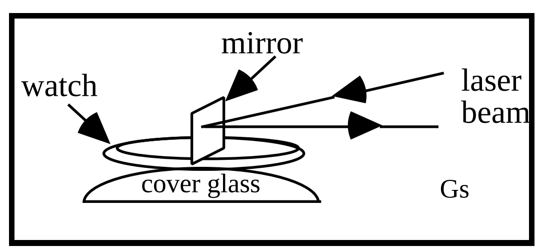
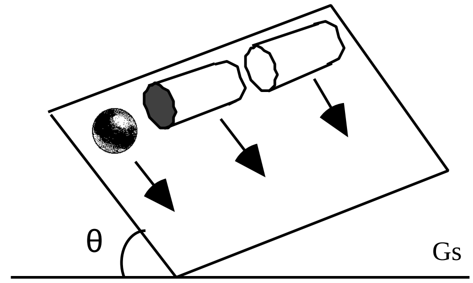
d) Ticking watch.

If pocket watch is carefully mounted on cover glass, motion of balance wheel will produce opposite movement of watch case. This can be observed by reflecting a laser beam off a mirror attached to the watch.



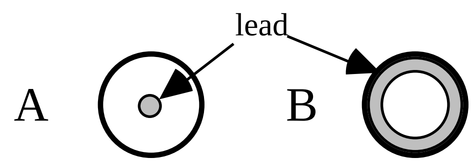
6. **Energy considerations**.

a1)Rolling object race on incline.



Roll three objects down plane: sphere, solid cylinder and hollow tube. Object with smallest moment of inertia will "win" the race. You can also roll objects of same geometry (e. g. spheres) but of different sizes. The acceleration is independent of the size. We also have a cylinder partially filled with sand. It stops about half-way down the plane!

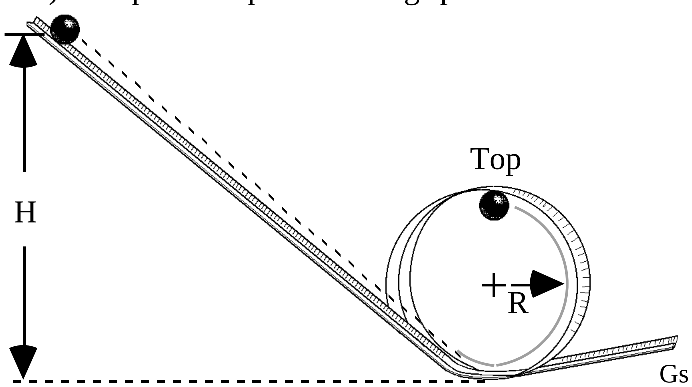
‘A’ has 1 1/4 inch lead cylinder in center.
‘B’ has 1 1/4 inch lead on outside of cylinder.



a2)Sliding vs rolling objects.

Use tilted air table to race a puck against a ball or cylinder.

b) Loop-the-loop with rolling sphere.

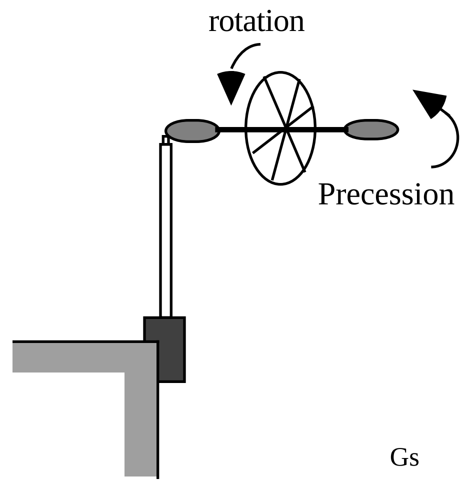


This is a repeat of previous experiment, but now we recognize that object is a sphere, so that some of KE at the top is rotational. A larger value of H is required, and a calculation gives H = 2.7 R (instead of 2.5 R for a point mass sliding without friction).

7. **Gyroscopic motion**.

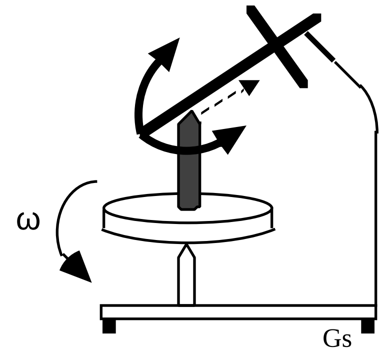
a) Precession.

The bike wheel makes a beautiful gyro visible to the whole class. Mount it on the edge of the lecture desk .



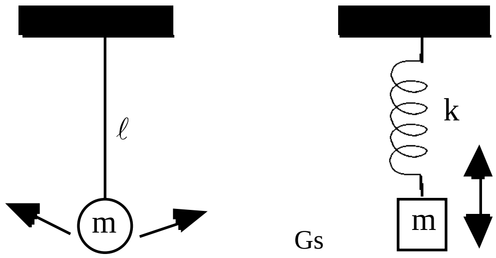
b) Symmetric top and "anchor."

We have a top supported at its center of gravity so that it is torque-free. The handle of the top can be brought into contact with the "anchor", and it will move along the anchor remaining in contact. (Must be seen to be believed!)



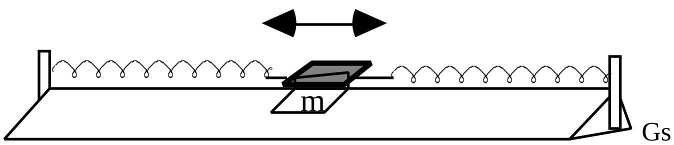
SIMPLE HARMONIC MOTION

1.

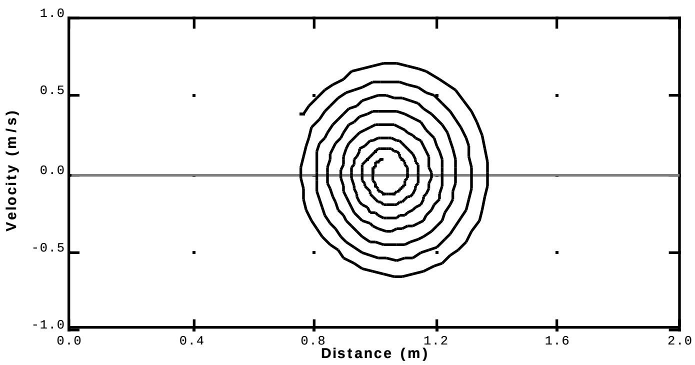


We have various springs and pendula that can be set up to show the basic features of simple harmonic motion.

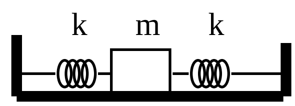
2. Air track or PASCO Carts



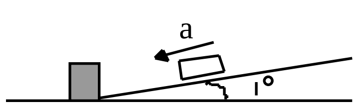
Rider on air track or PASCO Track can be set up to show practically undamped simple harmonic motion. By the use of two springs, complications of the constant gravitational force can be avoided.
(NOTE: On long air track, use a large rider with weights as one post.)

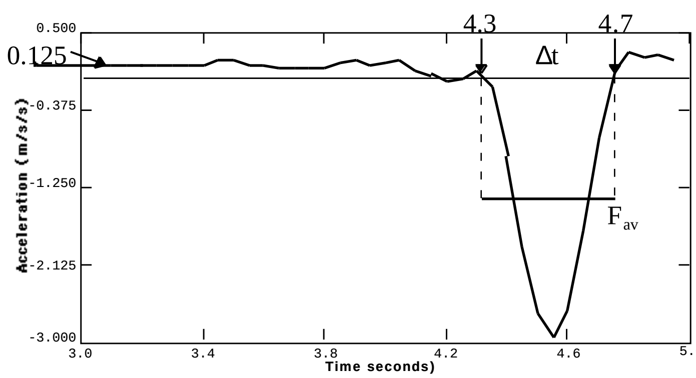


Area of ellipse E



This and the following MacMotion plots were done by J. Lopez in 1995.





$\Delta t = 4.7 - 4.3 = 0.4$ sec

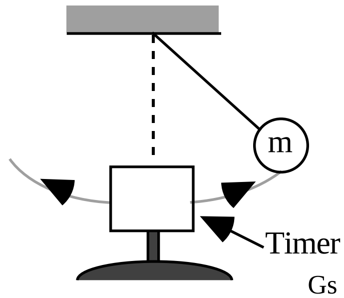
$I = \int_{t_i}^{t_f} F dt$ = area inside pulse

$I \approx (F_{max}\,\Delta t)/2 \approx 0.3$N. sec

$$F_{av} = \frac{1}{\Delta t}\int_{t_i}^{t_f} F dt \approx \frac{1}{\Delta t}\,\frac{F_{max}\Delta t}{2} = F_{max}/2$$

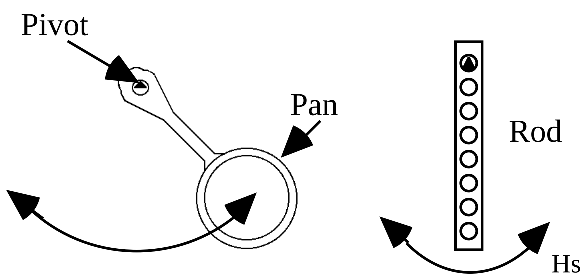
$$\frac{F_{av}}{W_{11}} = \frac{\frac{1}{2} m a_{max}}{mg\ \sin\theta} \approx \frac{\frac{1}{2} * 3}{0.125} \approx 12$$ < Force of collision much larger than other F_{ext}.

3. **Simple pendulum**.



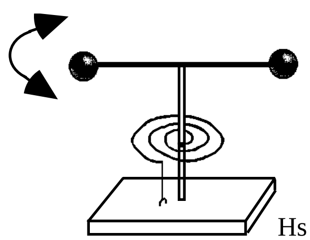
With simple pendulum and a PASCO timer, one can show the dependence of period on amplitude θ_o.

4. **Physical pendula**.



Use pan pivoted at end of handle or rod with holes to illustrate physical pendulum. (Period of rod depends on which hole is used for pivot.)

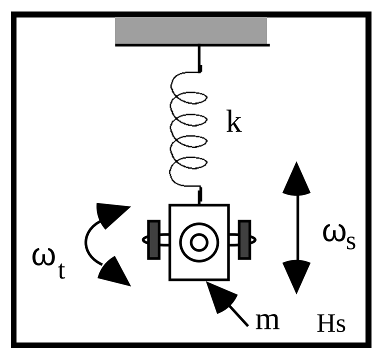
5. **Torsional oscillations**.



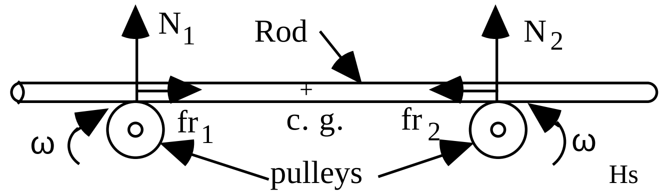
a) Rotational system with spiral spring can be used to show torsional oscillations. (Or, use "inertial balance" shown on page 3.)

b) **Wilberforce pendulum**.

Mass m oscillates on spring k. Twisting of spring when it stretches couples to the torsional mode of oscillation, ω_T. By adjusting screws on side of m, its moment-of-inertia can be adjusted so that ω_T ω_S. One then observes "beats" in which the energy is transferred slowly back and forth between the vertical motion and the torsional motion.



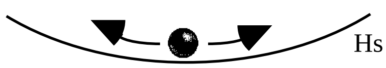
6. **"Gamow" oscillator**



A metal rod is supported on two pulley wheels in rapid rotation (ω). When c.g. of rod is mid-way between the wheels, $N_1 = N_2$, $fr_1 = fr_2$, and rod is in equilibrium. If c. g. is displaced to right, $N_2 > N_1$ and $fr_2 > fr_1$ and there is a restoring force. A little analysis shows that $fr_1 - fr_2$ -x, x = displacement of c. g. This is an interesting case, since here the friction force provides <u>no</u> damping. (In fact, the damping is negative, due to the velocity dependence of the friction force.)

7. **Ball in track**.

Ball rolling in circular track gives simple harmonic motion for small displacements.

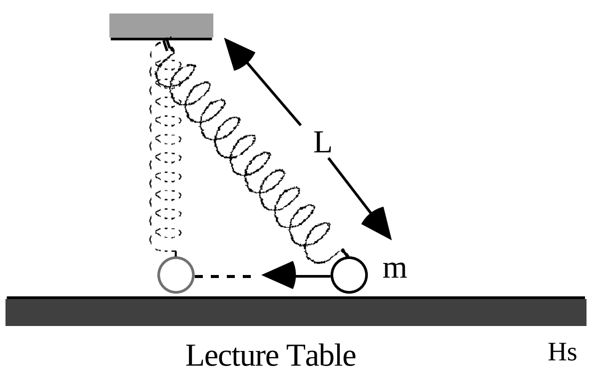


8. "**Rorschach Skimmer**".

Suspend large spring from ceiling support. Add mass m to spring so that equilibrium position is ≈ a few centimeters above table. If mass is displaced to end of lecture table and released from equilibrium height, it will move in a straight line parallel to table in simple harmonic motion. This motion requires that spring be a "zero length" spring -- i.e. that the force on m be proportional to the length of spring. This is satisfied closely enough when spring stretch is large.

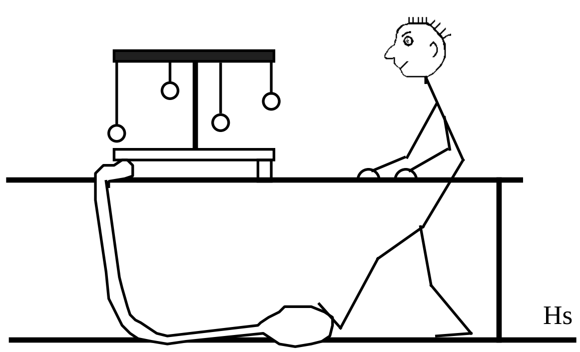
TOTAL MASS: = 2360 grams

1	50 gr.	1	kilo gr.
3	100 gr.	1	holder
1	500 gr.		



9. **Forced oscillations**.

Several ping-pong balls are suspended from a stand by threads of various lengths. Suggest to class that these are oscillators of various frequencies that are very sensitive to forces at the resonance frequency. Ask that they all concentrate on a given ball. After a few seconds, that ball begins to oscillate! The trick is that a rubber tube is mounted under one end of the stand. It can be pumped by foot-bulb so that the stand rocks slightly (imperceptible to the class). By timing the rocking, any desired ball can be set into motion by "telepathic forces!"

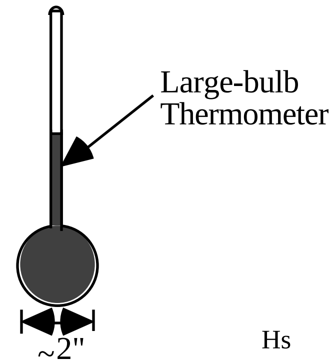


HEAT & THERMODYNAMICS

1. **Thermal expansion**.

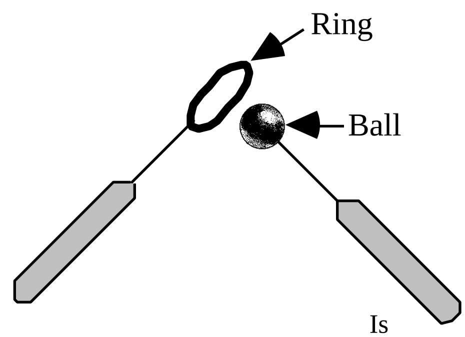
   a) Hg thermometer:

   Large-bulb thermometer. Image can be projected on to screen. When bunsen burner is applied to bulb, Hg level initially drops as glass expands before Hg is heated. As Hg heats, Hg rises in bulb.



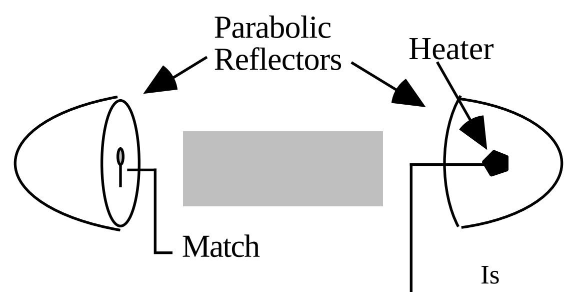
   b) Heat-fitting.

   At room temperature, ball will not fit in ring. When ring is heated, ball fits easily. Or, you can cool the ball in liquid N_2.



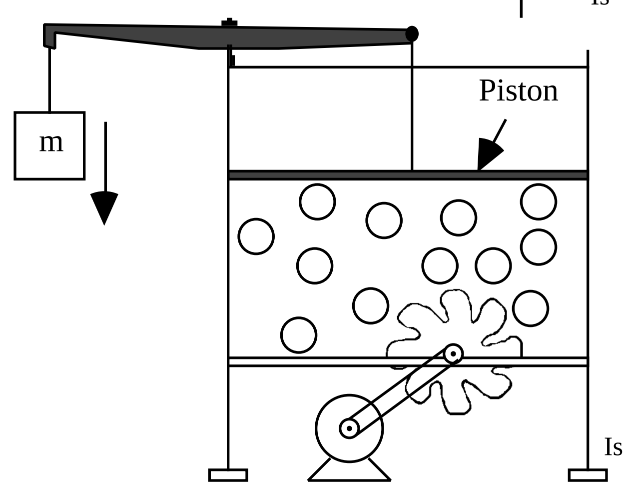
2. **Heat transfer**.

   Two parabolic reflectors can be set up, one at each end of lecture desk. An electric heater is at the focus of one and a match at the focus of the other. When heater is turned on, match will ignite!

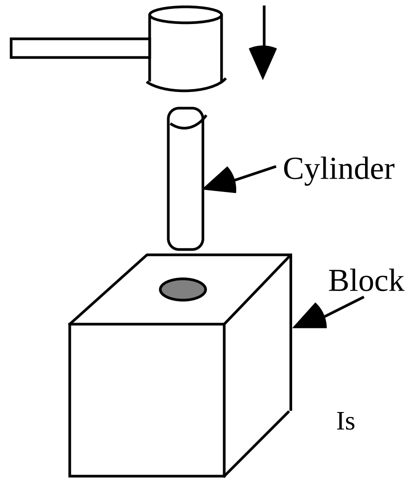


3. **Kinetic theory**.

   About 20 ping-pong balls are enclosed in a glass-walled container. A wavy wheel at the bottom is turned by a motor so that the balls are in "thermal" motion. Balls will collide with piston, exerting a "pressure" on it and causing a fluctuating displacement of the counter-weight m.



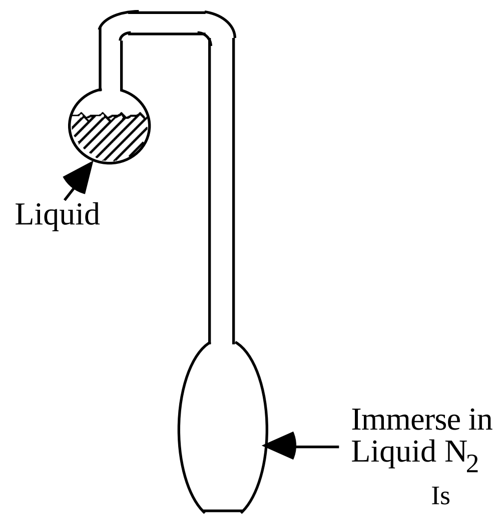
4. **Adiabatic compression**.



Steel cylinder fits tightly (with a little oil) into hole in steel block. A few match heads are placed in the bottom of the hole. If the cylinder is struck sharply by the (**large machine shop**) hammer while in the hole, the air is compressed sufficiently to ignite the match-heads. This creates a small explosion which will propel the cylinder a few feet into the air. (A good way to end your lecture with a "bang", instead of a whimper!)

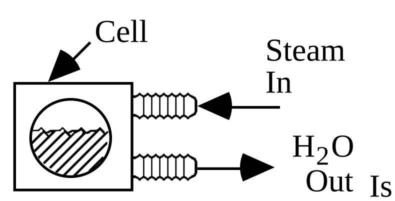
5. **States of matter**.

a) Cryophorous.



Cryophorous is adjusted so that liquid is in the upper (round) bulb. If the lower is immersed in liquid nitrogen, "cryopumping" will occur in the top bulb. The liquid will cool along the vapor pressure curve to the triple point, and ice will form as the liquid is boiling. (The upper bulb can be projected on the screen to show this.)

b) Critical point opalescence.



Critical point cell has proper amount of freon so that when heated, it passes at constant volume through the critical point. Near the critical point, many unusual things occur. The liquid boils, but large drops of "liquid" float in the vapor. There are large density fluctuations, and at the critical point the light-scattering is so strong that the vapor becomes milky-looking. Transmitted light is strongly reddish in color.

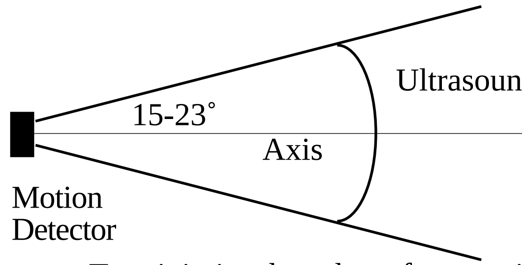
c) Transparencies are useful to discuss phase-changes. Especially helpful are:
1) Vapor pressure (P-T) curve.
2) P-V plots with T = constant lines.
3) P-V-T surfaces. (We have plaster model for CO_2 surface.)

MOTION DETECTOR TIPS:

First, keep in mind how the motion detector works. When you start data collection, it sends outa short burst of 40-kHz ultrasonic sound from the transducer. It then waits a few milliseconds and then starts to listen for and echo. As soon as a reflection of sufficient intensity is received, the motion detector will report an object detected. The sensitivity of the echo detection circuitry automatically increases, in steps, every few milliseconds as the ultrasound travels outward. This is to allow for echoes being weaker from objects at larger distances.

The most frequently reported problem with the motion detector is, "It doesn't work beyond 2 meters." Here are some of the things to check if you have this problem:

Check for stationary objects in the cone of the ultrasound. It may not take a very large object to return a good echo.The cone of the ultrasound extends from 15˚ to 23˚ off the axis of the motion detector.



To minimize the echoes from stationary objects, place a cloth over them.

Also note that the cone of the ultrasound is symetrical and extends downward fron the axis. On a hard horizontal surface, aim the detector slightly upwards.