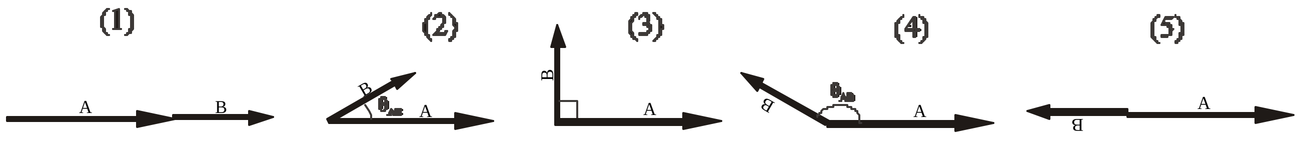
DOITs

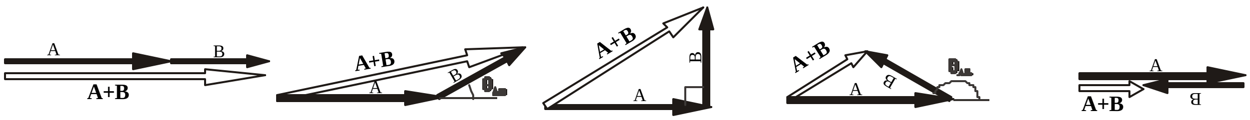
Phy 215 Sec 521 Dr. Hulan E. Jack Jr.

DOIT 1 and 2 ADDITION and SUBTRACTION of VECTORS -

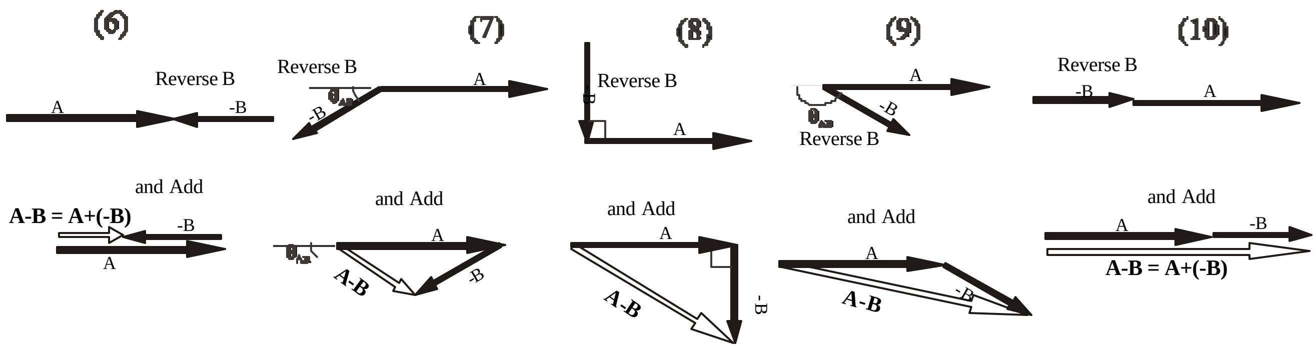
Graphical and Analytical Compared



Examples of ADDITION **A+B** Tip-to-Tail, Tip-to-Tail



Examples of SUBTRACTION **A-B = A+(-B)** **(Reverse B and Add)**



The scale here is lengths A = 25 mm and B = 15 mm and θ_{AB} = 30^0 and 150°, respectively. **Choose and list your own scale**. For example 50mm = 25 mm, so A becomes 50mm and B 30mm **KEEP ANGELS AND RELATIVE SIZES**

1. Do each addition and subtraction graphically as shown above. Measure **A+B** and **A-B** and their angle to **A**.
2. Do each addition and subtraction analytically. In each get the x and y components **A** and **B** and calculate the magnitudes and angle to A of **A+B** and **A-B**, and compare results of the two methods by calculating the percentage difference between the two.
3. in each write **A**, **B**, **A+B** and **A-B** in unit vector, ordered pair and polar representations.

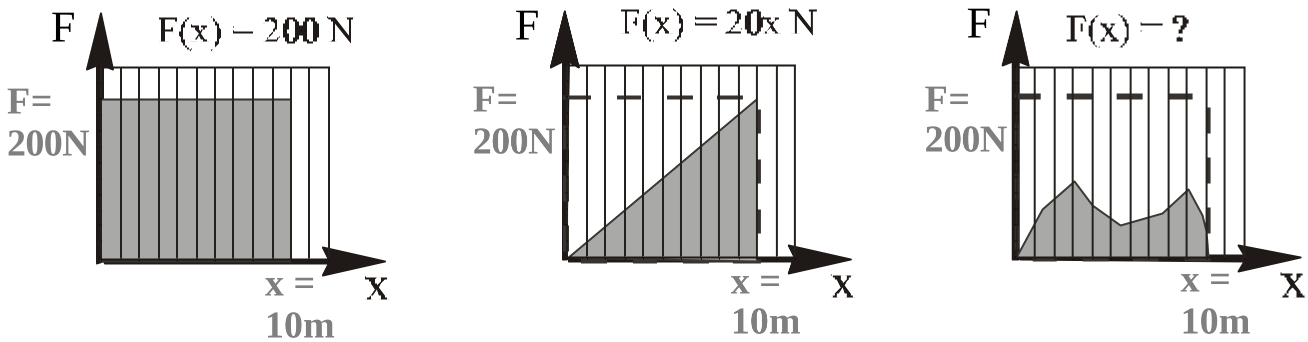
A SUGGESTED SAMPLE DATA TABLE

Note distribution of points for each of the 10 examples

Graphic Analysis Scale A =50cm,B=30cm	Analytical Analysis	%Difference
a. **2 points** **1 points** C_{graph} = cm θ_{graph} = ^{O}	**2 points** **1 points** C_{analyt} = cm θ_{analyt} = ^{O} **2 points** unit vector, ordered pair, and polar representations	**1p** $100 * \frac{C_{graph} - C_{analy}}{C_{graph}}$ **1p** $100 * \frac{\theta_{graph} - \theta_{analy}}{\theta_{graph}}$
b C_{graph} = cm θ_{graph} = ^{O}	C_{analyt} = cm θ_{analyt} = ^{O} unit vector, ordered pair, and polar representations	$100 * \frac{C_{graph} - C_{analy}}{C_{graph}}$ $100 * \frac{\theta_{graph} - \theta_{analyt}}{\theta_{graph}}$

DOIT 3 Areas

3.3 Some Examples and Exercise



The above three figures show various F (Force) vs x (displacement) curves. The product Fx is work which has the units Joules - 1 Joule = work done by a force of 1 N (Newton) applied for a displacement of 1 m (meter) in the direction of the force. The grid has 10 squares for 200 N on the vertical, 20 N high each, and 10 squares for 10 m on the horizontal, 1 m each. So, each grid square is 20 N high x 1 m wide, hence has an area of 20 Nm = 20 Joules.

1. **Use geometry to show that the rectangle has an area of 2,000 Joules, and the triangle an area of 1,000 Joules. If you have had calculus also verify these values using integration.**
2. **By counting the squares verify the values for areas of the rectangle and the triangle, and that the last curve has an unknown area depending on how you draw it. Describe your technique for counting the "squares". For examples, the rectangle and triangle do not require actually counting all the squares. For these two it is often adequate to count the number of squares along each side (even fractional squares) multiply the two numbers and multiply that result by 1 for the square and ½ for the triangle, respectively. Varied strategies can be, and must be used with irregular shapes.**
3. **By cutout and weighing get the weights of each curve. Use heavy cardboard, like from a box. Cut out each shaded area to scale. You can water log them to make them heavier. Get the weights and divide them into that of the rectangle. The triangle should weigh half as much, and the unknown curve about one-fourth as much. Multiply these fractions by the known 2,000 Joules (the scale) of the rectangle gives the areas of the others in Joules. You need a weighing scale that can measure small weight. You can use a diet scale or a ruler as a balance scale described in the section on torques. If you use the ruler, keep the rectangle on one side of the center and move the other area on the other side until they balance. The ratio of the distances is the fraction wanted. Describe how you made your measurements. Include a picture.**

DOIT 4 Relative Motion

Figure 1 shows the step by step details of a 1-D example of relative motion..

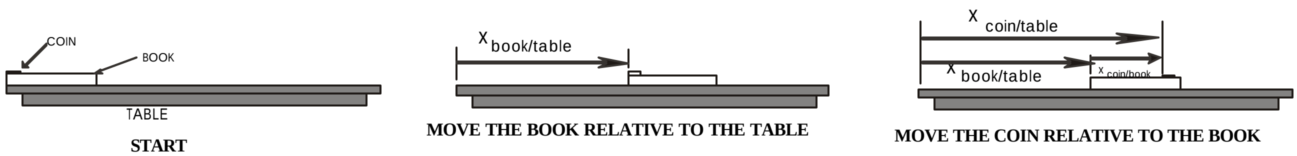


Figure 1

The relationships that describe this relative motion are

$$x_{\text{body/ground}} = x_{\text{medium/ground}} + x_{\text{body/medium}}. \quad (1)$$

Dividing through by the common time of travel, Δt, gives

$$v_{\text{body/ground}} = v_{\text{medium/ground}} + v_{\text{body/medium}}, \quad (2)$$

for the velocities. The view from the body relative to the ground is the vector sum of the view of the medium relative to the ground plus the view of the body relative to the medium. Do several examples. In each show a scaled diagram with lengths.

1 Dimensional Exercise:

Use the setup in Figure 1.

1 Sketch Figure 1 to scale for the details of your situation and put the numbers next to or above the symbolic names. List your scaling factor. 10 points

2 Assume the speed was constant,

calculate each of the velocities in Eq. 2 from Eq. 1. 20 points

Figure 2 shows the step by step details of a 2-Dimensional example .

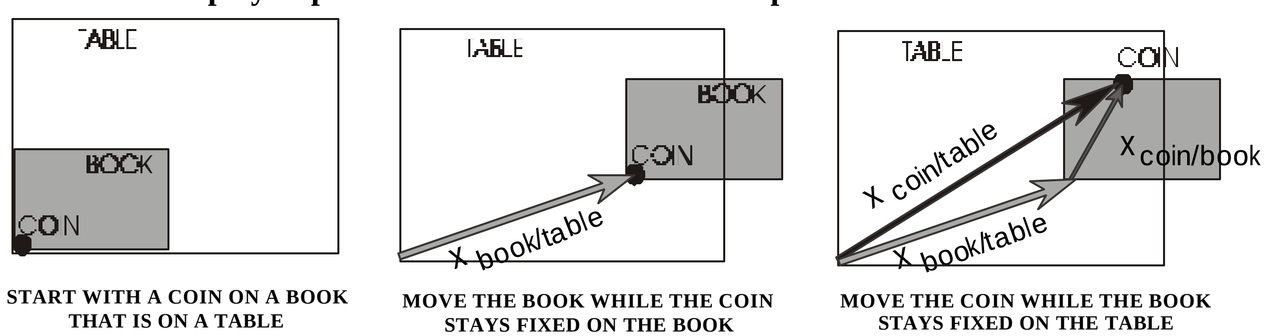


Figure 2

2Dimensional Exercise:

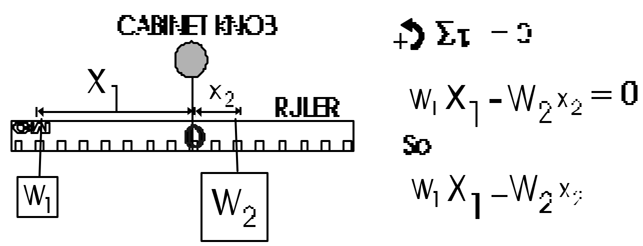
Use the setup in Figure 2.

1 Sketch Figure 2 to scale for the details of your situation and put the numbers, magnitudes and directions, next to or above the symbolic names. List your scaling factor. 25 points

2 Verify Eq.1 by the full vector calculations - get and use components of the vector. 35 points

DOIT 5 Balance Scale

Use Rotational Equilibrium - make homemade balance scale

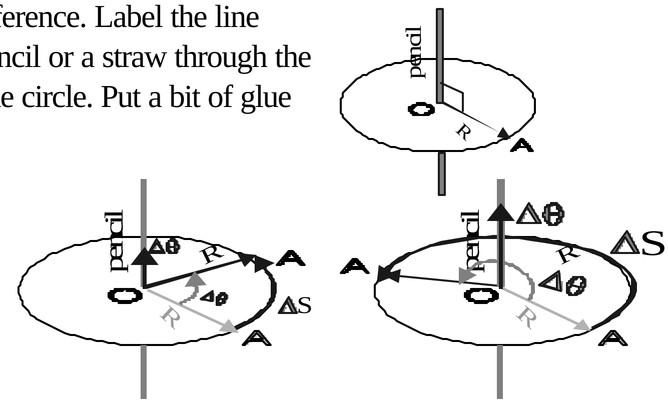


Trial number	w_1	x_1	τ_1	w_2	x_2	τ_2	comments

You might use this to do DOIT 3c .

DOIT 6 ROTATIONAL MOTION

6.8.1.1 Exercise: Review Sec 5.4.2. With a compass make a circle from cardboard . Make a line from the center to the circumference. Label the line OA.. Punch a hole in the center of the circle. Put a pencil or a straw through the hole, with the pencil or straw being perpendicular to the circle. Put a bit of glue where the pencil and the circle touch.

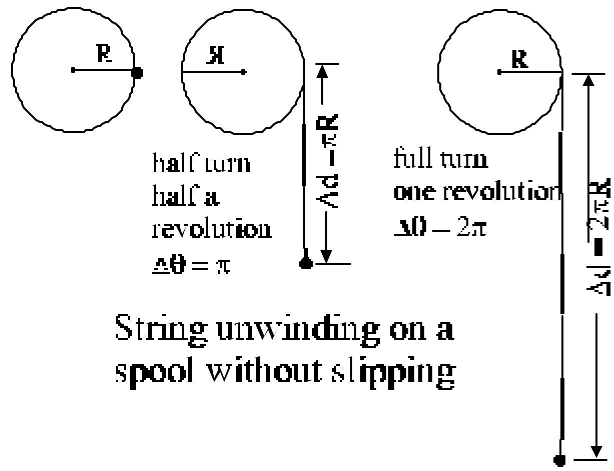


As you twist the pencil the circle turns. The line OA sweeps out larger angles $\Delta\theta$, the circumferential segment ΔS grows as in the above figures. Note that it you action on the axis perpendicular to the circle that is causing the rotation. So, the pencil is the axis of rotation. The rotation $\boldsymbol{\Delta\theta}$ is a vector along this axis of rotation. Describe what you observe as you it rotates, rotates fast, rotates slowly.

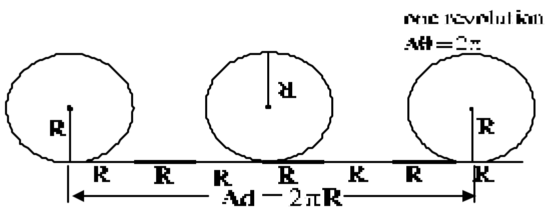
DOIT 7 Rolling Without Slipping

6.10 Rolling Without Slipping

Rolling without slipping is a very special case of rolling. It may be thought of as a type of rolling where the rotational motion and linear motion are uniquely mapped into each other. Each rotational displacement has a unique linear displacement, and vis-versa. The two figures show the situation for (1) a wheel rolling on a flat surface without slipping and a string unwinding from a spool without slipping.



String unwinding on a spool without slipping



Wheel rolling without slipping

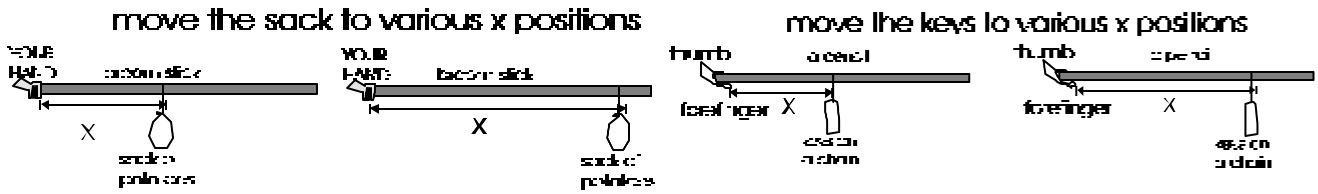
The relationship is $$\Delta d = R\Delta\theta ,$$
linear displacement = Radius x angular displacement .

6.10.1 Exercise:

Take a round object like a jar top that has a diameter of at least 50mm (radius = ½diameter , D =2R). Put a mark on rim . Use some moderately thick paper like the Sunday TV guide. Place the top on the paper with the mark touching the paper. Press down on the top as you roll the it in a straight line along the paper without slipping. Measure the diameter of the top and the length of the groove left in the paper. Do it again but allow the top to occasionally slip or skid on the paper.

DOIT 8 Experience Torque

7.3 Exercise: Experience Torque



As you move the load, the sack or keys, record the distance x and your observations - what do you feel. How hard or easy is it for you to support this situation. Use several "sacks" of different masses.

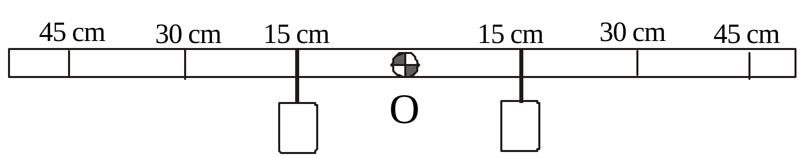
Sample Data Sheet

Load - Item	Load Weight	x	Torque	your experience
Potato Sack	5 p	1 ft	5p x 1f = 5 pf	easy to support
Potato sack	5 p	3 ft	5p x 3f = 15 pf	almost broke my wrist - couldn't handle it!

DOIT 9 Experience Moment of Inertia

7.4 Experience Moment of Inertia I_o

1. Unscrew a broom stick from a broom.
2. Find the center of mass of the stick by finding the point at which it balances.
3. Mark this point. Mark off 15 cm, 30 cm and 45 cm on both sides of the stick.
4. Tie equal weights at the two 15 cm marks one on each side of the center. The weights might be two 5 p sack of potatoes, two 1 p boxes of sugar.
5. Hold the loaded stick try gently rotating by a few degrees. Record your feelings.
6. Move the weights to the two 30 cm marks. Do 5 again.
7. Move the weights to the two 45 cm marks. Do 5 again.
8. Use two new weights that are equal to each other but different from the first set. Do 5 to 7 again.

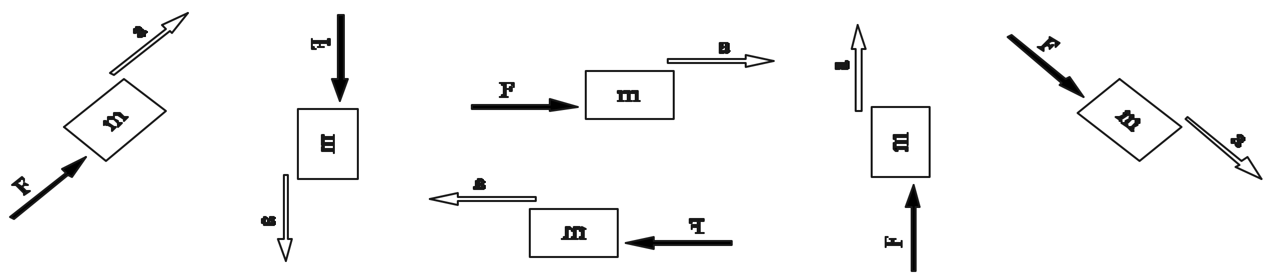


Sample Data Sheet

Item and weight	position	$I_o = \Sigma m_i r_{io}^2$	comment
potato sack 5 p = 2.27 kg	30 cm =0.3m	2x(2.27kgx(0.3m)^2 = 0.409 kg m^2	very hard to rotate
sugar 1 p= 0.453 kg	15 cm = 0.15m	2x(0.453kgx(0.15m)^2 = 0.0204 kg m^2	very, very easy to rotate

DOIT 10 Newton 2nd Law

Note the directional relationship between the causing force **F** and the resulting (the response) acceleration **a** .



7.2.2.1 Examples:

4. A body of mass m = 4 kg experiencing a net external force **F** = 24 N East. What is its acceleration?

   F = m**a**. So, **a** = **F**/m = 24 N East / 4 kg = (24/6) m/s^2 East = 4 m/s^2 East

5. A body of mass m = 5 kg is undergoing an acceleration **a** = 10 m/s^2 45° South of East. What is the causing force **F** ?

   F=m**a**, **F** = 5 kg x 10 m/s^2 45° South of East = (5x10) (kg m/s^2) 45° South of East = 50 N 45° South of East.

7.2.2.2 Exercise

1. Get several objects of widely varying masses (observed through their weight). Place them on a smooth table or floor. Using about the same force, hit each object in many different directions. Record the “amount of force” and its direction, the mass of the object and its response for each hit.
   Levels of Forces: Avery small force might be one where only the fingers of the hand move as hard as you can - the hand itself does not move at the wrist. A larger force might be a wrist slap - the whole hand moves as hard as you can at the wrist. The next level of force might be where the forearm moves at the elbow as hard as you can - no movement of the upper arm except for rotation. In each case “as hard as you can” will be more reproducible than to do it “softly”, then a little harder” , and so on. Also show a pictures of some of your examples.

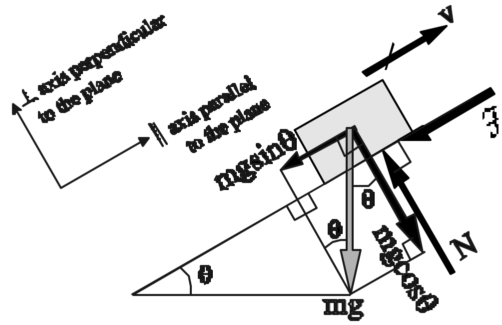
Sample Data Sheet

Object and its mass	Force		Response	
	Magnitude	Direction	Magnitude	Direction
can of soup 16 oz	*Hard*	*to the left*	*quickly, moved 12"*	*to the left*

DOIT 11 Inclined Plane Angles

8.1 Exercises:

8.1.1 Show that the angle of the inclined plane θ is also the angle between the weight mg and its component (mgcosθ) perpendicular to the inclined plane as shown in the diagram.



DOIT 12 Friction Slide

8.1.2. **DO THE FRICTION SLIDE** (It's corny but it makes a point)

1. First, stand and put your feet together. Lift your weight off your right foot and slide it to the front. Then lift your weight off your left foot and slide it to your right foot. Weight off your right foot and slide it to the back. Weight off your left foot and slide it to your right foot.
2. Now put a little weight on your right foot and slide it to the front. A little weight on your left foot, slide to your right foot. Then slide back as before with a little weight on the sliding foot.
3. Do it all again with more weight on the sliding foot.
4. Finally, with as much weight as you can put on t the sliding foot, slide, slide , slide.

WHAT DO YOU OBSERVE?

Use as many **foot-floor** variations as you can.

Foot - Bare, cotton sock, nylon sock, wool sock, leather soled shoes, rubber soles shoes (sneakers)

Floor - Smooth wood, vinyl tile, linoleum, ceramic tile (often in the bathroom), bath tube or shower floor.

SAMPLE DATA SHEET

Foot	Floor	Weight on sliding foot	Comments
in cotton sock	ceramic tile	light	slides very ,very easily
in cotton sock	ceramic	very heavy	slides with some difficulty

ANOTHER FORM OF DATA SHEET

Combinations		Weight on sliding foot			Sliding the foot			
Foot	Floor	light	moderate	heavy	easy	not easy	hard	didn't
sneaker	tile		x				x	
sneaker	tile			x				x

DOIT 13 Measure the Coefficients of Friction

Get a hard cover book , a protractor , some objects like coins, a tape cassette case, pieces of various kinds of paper and cloth materials , for each one piece the size to wrap around , tape to, or glue to, the tape cassette case and another piece large enough to cover the surface of the book..

1. Place a coin on the book while it is in a horizontal position. Then raise the angle of the book until the coin just starts to slide. Measure this angle with the protractor and record it. The tangent of this angle is the coefficient of static friction. Next holding the book at an angle for which the coin slides. Lower the angle until the coin just stops sliding. Measure and record this angle. The tangent of this angle is the coefficient of kinetic friction.
2. Next, cover the surface of the book with a piece of smooth notebook paper. Measure and record the above two angles for the sliding coin on this paper.
3. Next, cover the surface of the book with a piece of newspaper. Measure and record the above two angles for the sliding coin on this paper.
4. Next, cover the surface of the book with a piece of glossy paper. Measure and record the above two angles for the sliding coin on this paper.
5. Next, cover the surface of the book with a piece of cloth. Measure and record the above two angles for the sliding coin on this surface.
6. Now using a tape cassette case, first bare, then covered with the smooth notebook paper, then with newspaper, then with the glossy paper, with the cloth, measure and record the two angles for these sliding down all of the previous surfaces on the book.

You may not have time for all of these variations. But, do at least a dozen variations once each. Also do at least one ten times and calculate the average and standard deviation.

SAMPLE DATA SHEET

Item	Surface	Angle Start	μ_s	Angle Stop	μ_k
quarter(clean)	newspaper	24^o	0.445	18^o	0.325
quarter (clean)	notebook cover	31^o	0.601	23^o	0.424

DOIT 14 Experience Stress

1. With both hands facing down, place one hand on top of the other. Press the top flat hand down with about a 5 p force.
2. Now ball you fist and press down on the back of your hand using the flat fist using same force as above.
3. Next , press down on the back of hand with one knuckle using the same force as above - if you can!

Describe what you feel in each case.
Note that if you do this with a sharp pencil or pen point, you would find the experience most penetration - literally.

DOIT 15 Simple Pendulum

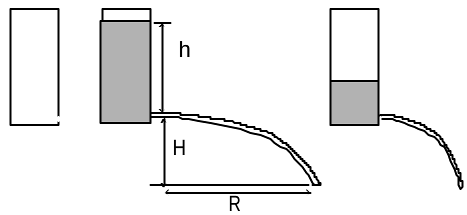
Simple Pendulum. Use a few objects of different masses. For each, attach it to a thin string or thread and let is swing at different string lengths. Record length L and period T. To measure the period T measure the time that it takes for the weight to do 10 to 20 swings. This time divided by the number of swings give the period. Plot L(vertical) vs T (horizontal) and L vs T^2. Discuss any patterns that you found. For samples, see SIMPLE PENDULUM in the Lab Manual.

DOIT 16 Water Flow From a Faucet

Watch the water stream falling from your faucet when the flow is steady. Why does it get narrower as it falls?

DOIT 17 Water Stream

A can or bottle has a small hole near its bottom. The has water at a height h above the hole and the hole is a height H above the ground. The water stream from the hole hits the ground a horizontal distance R from the hole as shown in the picture.



a Show that $H=R^2/4h$ (derive it).

2. Do it. Perform it as an experiment. Set H fixed, measure h and R. Do it again for a total of at least three values of H. Compare measured values with the above equation.

Sample Data Sheet

H (fixed)	Measured		Calculated		% Diff	
	h	R	h	R	h	R