ACTIVITY 7: BELT SANDER

TECHNOLOGICAL FRAMEWORK: Friction is a force which is undesirable when considering the inner working of machinery, but it is a very desirable force when considering surface finishing. All types of manufacturing processes produce rough-edged or rough-textured parts which need deburring. Sanding these parts may be effective if the part surfaces are large and flat.

PURPOSE: To understand how a belt sander uses friction.

To calculate the normal force of a weight on an inclined plane.

To explain the relationship between f, mu, and the normal force.

To investigate the coefficient of friction when changing angles and changing grades of paper.

ILLINOIS LEARNER OUTCOMES: As a result of their schooling, students will have a working knowledge of:

- The concepts and basic vocabulary of biological, physical, and environmental sciences and their application to life and work in contemporary technological society.
- The principles of scientific research and their application in simple research projects.
- The processes, techniques, methods, equipment, and available technology of science.

CONCEPTS: Physics--kinetic friction

Mathematics--right triangle trigonometry

Technology--surface finishing

PRE-REQUISITES: Knowledge of frictional forces including coefficient of friction and normal force

MATERIALS, EQUIPMENT, APPARATUS:	Belt sander assembly (instructions at the end of the activity) Spring scale (10-25 lb. capacity) Block to be sanded Coarse and fine sand paper
TIME FRAME:	45 minutes
TEACHING STRATEGIES:	Physics or Technology lab Physics or Technology teacher to give presentation Mathematics teacher to review present triangle trigonometry
TEACHING METHODOLOGY:	Discussion of measuring frictional forces on horizontal surface and inclined plane Discussion of lab setup and operation Lab activity Post-lab discussion of results
FURTHER FIELDS OF INVESTIGATION:	Other methods of surface finishing such as shot peening or vibratory finishing are also used.

PROCEDURE:

Friction can be a positive or a negative factor in machinery. A motor must overcome friction to operate, while a belt sander uses friction to create a smooth surface.

In this lab, you'll measure the force applied by a belt sander to a wood surface to determine the coefficient of friction. You'll see how changing the angle of the belt sander affects the force applied and the coefficient of friction. To determine the normal force when the plane is at an angle, you will use right triangle trigonometry.

You will determine the coefficient of friction by drawing a graph that models the data from your measurements. The slope of this line should be the coefficient of friction.

1. Place a fine grade of sandpaper (120) on the sander.

2. Weigh the belt sander and record.

3. Place the sander in the brace and attach the spring scale to the ramp and sanding board. Follow the setup shown in Figure M-7-1, "Belt Sander Setup."

4. Using the weight of the sander and right triangle trigonometry, compute the normal force and record the results in Table M-7-1, "Belt Sander Data--120 Grade." (Use: wt. of sander x $\cos\theta = N$)

5. With plane set at the horizontal level, turn on sander and record the frictional force reading from the scale.

6. Adjust the plane angle to first setting (10 degrees), turn on the sander, and record the frictional force.

7. Repeat for each angle, 20, 30, and 40 degrees.

8. Change the belt on the sander to a more coarse grade of paper (60).

9. Repeat steps 2-7 above, recording all values in Table M-7-2, "Belt Sander Data--60 Grade."

10. For each data table, graph f vs. N. (the frictional force vs. the normal force).

11. Compute the slope of each graph. The slope is the coefficient of friction for the sander and the board.

    Note: The parallel components of the weight of the board and the sander are important but, because of the design of the apparatus, their effects are negligible.

POST-LAB QUESTIONS: BELT SANDER

1. What is friction?

2. List several examples of situations where friction is desirable.

3. List examples of undesirable friction.

4. Describe the relationship between frictional force and normal force.

5. In this experiment, how does the coefficient of friction for the coarse sandpaper compare to that of the fine sandpaper?

6. What factors could influence the results of this experiment?

7. If the coefficient of friction between the two surfaces is .64, what horizontal force will be necessary to pull a 75-pound wooden crate across a concrete floor at a constant speed?

8. What force will be needed to pull the same crate from problem #7 up a 25° concrete incline?

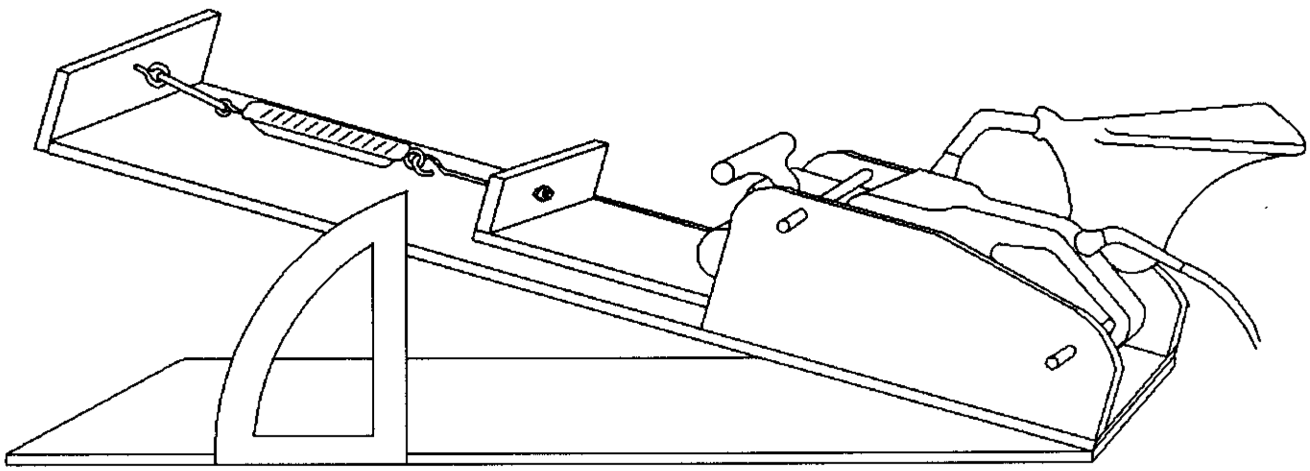

Figure M-7-1

Belt Sander Setup

Table M-7-1

Belt Sander Data--120 Grade

Trial	Angle of Plane (degrees)	Normal Force N (pounds)	Frictional Force f (pounds)
1	0		
2	10		
3	20		
4	30		
5	40		

Table M-7-2

Belt Sander Data--60 Grade

Trial	Angle of Plane (degrees)	Normal Force N (pounds)	Frictional Force f (pounds)
1	0		
2	10		
3	20		
4	30		
5	40		

ANTICIPATED PROBLEMS:

Multiple trials may be needed to do the experiment.

Have a new clean belt for the sander.

The surface between the ramp and the sanding plate should be as frictionless as possible, i.e., use ball bearings imbedded in the ramp.

Use a hardwood board for the sanding plate. Knots in the wood may cause uneven wear.

METHODS OF EVALUATION:

Answers to questions

Class discussion on friction

Quiz

FOLLOW-UP ACTIVITIES:

Test a variety of hard and soft woods with the the apparatus

Tour a plant to view industrial finishing systems' use of friction

Demonstrate a rock polisher

View the video "Total Surface Finishing."

Have the students investigate static friction associated with surface finishing by performing the following activity:

<u>Friction of Finished Surfaces</u>

Purpose: To measure the coefficient of friction between wood surfaces of varying smoothness.

Apparatus:

1 wood block, approximately 2" x 4" x 3"
1 unfinished board, approximately 1" x 6" x 18"
1 protractor
1 sanding block
1 coarse sandpaper
1 medium sandpaper
1 fine sandpaper
Varnish
1 brush

1. Cut a block of wood from a 2" x 4" wood block and sand it with a medium grade sandpaper.

2. Weigh the block and record the weight in Table M-7-3, "Follow-Up Data Table."

3. Cut an unfinished board approximately 1" x 6" x 18" and set the end of it against a rigid object so that it will not slide when the free end is lifted.

4. Place the block of wood on the free end of the unfinished board.

5. Slowly raise the free end of the board which has the block on it until the block begins to slide down the board.

6. Record the angle at which the block begins to slide.

7. Use the weight of the block and the angle to calculate the normal and the frictional forces acting on the block.

$$F_{normal} = F_{weight} (\cos \theta)$$

$$F_{frictional} = F_{weight} (\sin \theta)$$

8. Calculate the coefficient of friction (μ) for the block and board.

$$\mu = \frac{F(frictional)}{F(normal)}$$

9. Repeat the experiment four more times by using coarse, medium, and fine sandpaper to finish the board to various degrees of smoothness and end with the last trial after the board has been coated with varnish.

Table M-7-3

Follow-Up Data Table

Board Surface	Angle (degrees)	F_{normal} (pounds)	$F_{frictional}$ (pounds)	μ
Unfinished				
Coarse				
Medium				
Fine				
Varnished				

REFERENCES, RESOURCES, VENDORS:

K.V.F. Quad Corporation
1201 7th
East Moline, IL 61244
(309) 755-1101

For surface finishing video, write to:
Finishing & Associates, Inc.
975 Jaymor Rd., Suite #5
South Hampton, PA 18966
(215) 953-1340

BELT SANDER APPARATUS

Parts List:

1 - 3/4" x 6-3/4" x 34-1/2" plywood base

2 - 3/4" x 7" x 13" plywood sides

1 - 3/4" x 2-3/4" x 6-3/4" plywood rear block

1 - 3/4" x 2-1/2" x 6-3/4" plywood front block

2 - 3/8" x 1-1/4" x 18" plywood sanding plate guides

6 - ball bearings - 3/8" to 1/2" all the same size

2 - 1/2" dowel rods 10" long

2 - 1/4" x 1-1/2" eyebolt nut and washer

1 pound of 1-1/2" to 2" drywall screws

1 - 3/8" x 4-1/4" x 17-1/4" piece of solid wood (not plywood) for sanding plate

Assembly

Note: The belt sander test platform was built for the Porter Cable Model 360 Heavy Duty Dustless Belt Sander. If you do not have this model sander, you may have to modify your test platform to fit your sander.

1. Cut all pieces to the sizes listed in the Parts List. Check Figure M-7-2, "Belt Sander Apparatus Drawing," for detail information.

2. Start with the base. To reduce friction between the sanding plate and the base, drill six holes for the ball bearings. Drill about 2/3 the depth of the bearing and press wax or grease into the hole. Then press the bearings into the holes.

3. Fasten the sides to the base. The base fits between the sides. The rear block fits between the sides and on top of the base. Fasten all these parts with screws. Fasten the front block with the eye bolt to the front of the base as shown in Figure M-7-2.

4. The sanding plate guides are fastened to the base just inside the sides and touch the rear block. The space between them must be wider than the sanding plate which is 4-1/4" wide for the sander.

5. The sanding plate is a 4-1/4" x 17-1/4" x 3/8" solid wood (not plywood). One end has a 3/4" x 2" x 4" block screwed on to hold the other eye bolt. The sanding plate sets on the bearings between the sides. Place the sander on the plate and place the dowel rods in the holes to hold the sander in place. This setup is fastened on an adjustable inclined plane for testing.

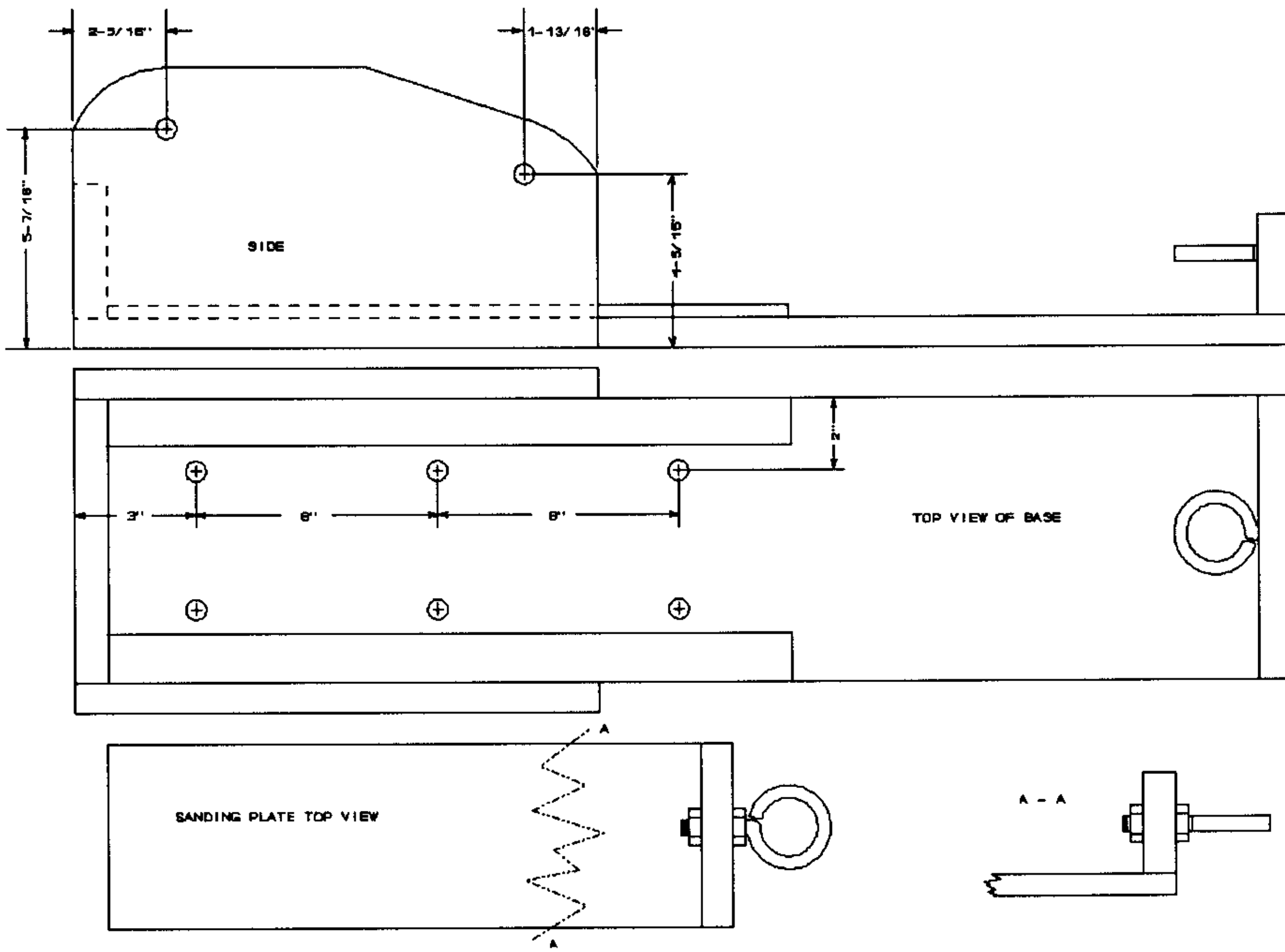

Figure M-7-2

Belt Sander Apparatus Drawing

PHYS-MA-TECH

AN INTEGRATED PARTNERSHIP

FRICTION BELT SANDER MATHEMATICS WORKSHEET

Right Triangles and Trigonometric Functions

Note: A prerequisite for this worksheet is a discussion of vectors.

Facts about right triangles:
(See Figure M-7-3, "Triangle A.")

- Contain one 90° angle.
- The other two angles are called acute (have measures of less than 90°).
- Contain three sides; the longest side is directly across from the right angle and is called the hypotenuse.
- The shorter sides are called legs.
- The sum of the three angles is 180°.

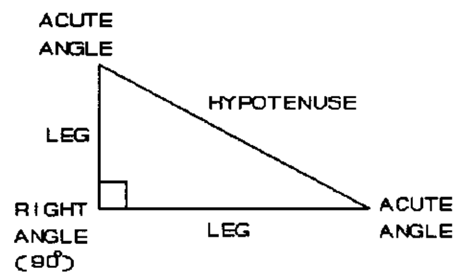

Figure M-7-3

Triangle A

Trigonometric functions can be used to determine angle measurements, unknown lengths or, in the case of vectors, unknown forces, velocities, and other vector quantities.

The trigonometric functions used here will be sine, cosine, and tangent. Their definitions are as follows (see Figure M-7-4, Triangle B"):

$$\sin\theta = \frac{a}{h} = \frac{\text{opposite lef}}{\text{hypotenuse}}$$

$$\cos\theta = \frac{b}{h} = \frac{\text{adjacent leg}}{\text{hypotenuse}}$$

$$\tan\theta = \frac{a}{b} = \frac{\text{opposite leg}}{\text{adjacent leg}}$$

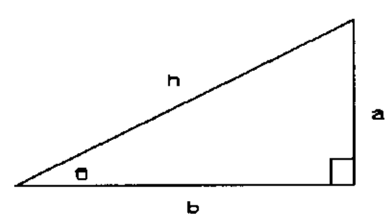

Figure M-7-4

Triangle B

The expression $\sin\theta$ is read as "sine of theta," where theta is the acute angle. Sin, cos, and tan are abbreviations for sine, cosine, and tangent, respectively. These ratios are always written with respect to a certain angle.

1. Using the triangle in Figure M-7-5, "Triangle C," write the ratios for each of the following:

sinA =   sinB =

cosA =   cosB =

tanA =   tanB =

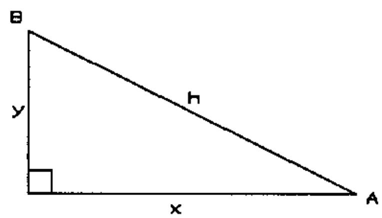

Figure M-7-5

Triangle C

The following example will illustrate how to determine the values associated with the legs of a right triangle, given information about the hypotenuse and one acute angle.

2. c is a vector quantity of force. Find the magnitude (size) of its perpendicular components (see Figure M-7-6, "Triangle D").

$c = 45$ N

$\theta = 23^\circ$

First, write the correct ratios using the labels given.

$\sin\theta =$ $\cos\theta =$ $\tan\theta =$

To find "a," use $\sin\theta$.

Rearrange the equation. Solve for "a."

$a = \sin\theta \times c$

$a = \sin(23^\circ) \times (45\ N)$

$a = 0.3907 \times 45\ N$

$a = 17.6\ N$

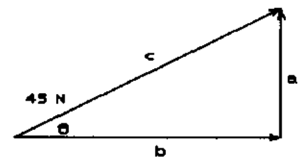

Figure M-7-6

Triangle D

To find "b," use cosθ.

Rearrange the equation. Solve for "b." Complete as for "a."

Thus, the magnitudes of the components of the 45 N force are 17.6 N and __________.

Try the following problem using the above method.

3. A balloon is ascending at a rate of 12 ml/hr at an angle of 55 with respect to the ground. Find the speed of the wind pushing the balloon sideways and the vertical speed of the balloon (see Figure M-7-7, "Triangle E").

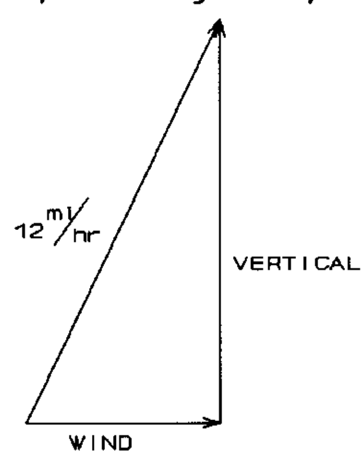

Figure M-7-7

Triangle E