

Math Skills Laboratory

Lab **2^M1^S**

MATH ACTIVITIES

Activity 1: Measuring Angles in Radians

Activity 2: Solving Mechanical Work Problems

MATH SKILLS LAB OBJECTIVES

When you complete these activities, you should be able to do the following:

- 1. Given an angle in degrees, find its value in radians.*
 - 2. Given an angle in revolutions, find its value in radians.*
 - 3. Solve mechanical work problems.*
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LEARNING PATH

- 1. Read the Math Skills Lab. Give particular attention to the Math Skills Lab Objectives.*
 - 2. Study examples in paragraphs C, D and E of Activity 1.*
 - 3. Work the problems for Activities 1 and 2.*
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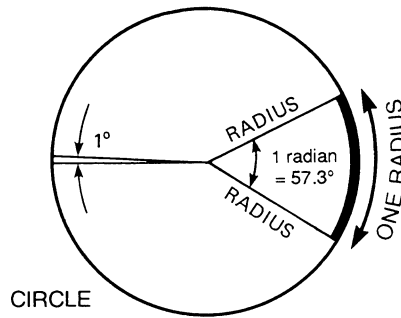
ACTIVITY 1

Measuring Angles in Radians

MATERIALS

For this activity, you'll need a protractor and a hand calculator.

- A. The **radian** is a unit of angle measure. It's like a degree, only much larger. It's equal to 57.3° . The radian is defined in terms of a part of a circle. An angle of one radian cuts off an arc on the circle equal to the radius of the circle, as shown on the next page. For comparison, the size of one degree is also shown.



- B. In terms of revolutions, degrees and radians, we have the following relationships:
 1 revolution = 360° (The symbol “°” stands for degree.)
 1 revolution = 6.28 radians (abbreviated “rad”)
 1 radian = 57.3°

- C. When **changing degrees to radians**, multiply angle in degrees by the fraction $\frac{1 \text{ radian}}{57.3 \text{ degrees}}$. This fraction is equal to *one*!

Example: Change 90° to radians.

$$(90 \cancel{\text{ degrees}}) \times \left(\frac{1 \text{ radian}}{57.3 \cancel{\text{ degrees}}} \right) = \underline{\underline{1.57 \text{ rad}}} \quad (\text{Cancel degrees.})$$

Example: Change 287° to radians.

$$(287 \cancel{\text{ degrees}}) \times \left(\frac{1 \text{ radian}}{57.3 \cancel{\text{ degrees}}} \right) = \underline{\underline{5.01 \text{ rad}}} \quad (\text{Cancel degrees.})$$

- D. When **changing revolutions (rev) to radians**, multiply angle in revolutions by the fraction $\frac{6.28 \text{ radians}}{1 \text{ revolution}}$. This fraction is equal to *one*!

Example: Change 2.5 revolutions to radians.

$$(2.5 \cancel{\text{ rev}}) \times \left(\frac{6.28 \text{ rad}}{1 \cancel{\text{ rev}}} \right) = \underline{\underline{15.7 \text{ rad}}} \quad (\text{Cancel rev.})$$

Example: Change 10 revolutions to radians.

$$(10 \cancel{\text{ rev}}) \times \left(\frac{6.28 \text{ rad}}{1 \cancel{\text{ rev}}} \right) = \underline{\underline{62.8 \text{ rad}}} \quad (\text{Cancel rev.})$$

- E. Measure the following angles with a protractor. Change angle in degrees to angle in radians.

Example:

θ measured = 60°

θ in radians is equal to:

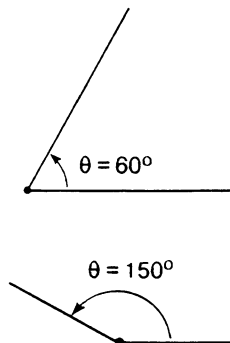
$$60^\circ \times \left(\frac{1 \text{ rad}}{57.3^\circ} \right) = \underline{\underline{1.05 \text{ rad}}}$$

Example:

θ measured = 150°

θ in radians is equal to:

$$150^\circ \times \left(\frac{1 \text{ rad}}{57.3^\circ} \right) = \underline{\underline{2.62 \text{ rad}}}$$



PRACTICE EXERCISES FOR ACTIVITY 1

Problem 1: Change each angle in degrees to an angle in radians.

(Remember, 1 radian = 57.3°.)

- a. $30^\circ = \underline{\hspace{2cm}}$.
- b. $57.3^\circ = \underline{\hspace{2cm}}$.
- c. $360^\circ = \underline{\hspace{2cm}}$.

Problem 2: Change revolutions to angle in radians.

(Remember, 1 revolution = 6.28 radians.)

- a. 0.5 revolution = $\underline{\hspace{2cm}}$.
- b. 5 revolutions = $\underline{\hspace{2cm}}$.
- c. 3.2 revolutions = $\underline{\hspace{2cm}}$.

Problem 3: Draw an angle of 85° with a protractor. What's the angle equal to in radians?

ACTIVITY 2

Solving Mechanical Work Problems

MATERIALS

For this activity, you'll need a hand calculator.

Mechanical work formulas needed for this activity are given below. The work formulas include formulas for linear mechanical work, torque, rotational mechanical work and efficiency. You'll need to choose the proper formula to solve each problem for the unknown value. Your final answer should include a *correct numerical answer* AND the *proper units*. Do a careful "unit-analysis" in each problem. Some unit relations are also given below.

$$\text{Work} = \frac{\text{Force Applied to Object}}{\text{to Object}} \times \frac{\text{Distance Object Moves While Force Acts}}{\text{While Force Acts}} \qquad W = F \times D; \quad F = \frac{W}{D}; \quad D = \frac{W}{F}$$

$$\text{Work} = \text{Torque Applied} \times \text{Angle Moved Through} \qquad W = T \times \theta; \quad T = \frac{W}{\theta}; \quad \theta = \frac{W}{T}$$

$$\text{Torque} = \text{Force Applied} \times \text{Lever Arm} \qquad T = F \times L; \quad F = \frac{T}{L}; \quad L = \frac{T}{F}$$

$$\text{Eff (\%)} = \frac{\text{Output Work}}{\text{Input Work}} \times 100 \%$$

$$1 \text{ N}\cdot\text{m} = 1 \text{ joule}; \quad 1 \text{ in.} = 2.54 \text{ cm}$$

PRACTICE EXERCISES FOR ACTIVITY 2

Problem 1: Given: A horizontal force of 50 newtons is applied to push a desk 40 meters across a warehouse floor.

- Find:
- a. How much work is done to move the desk?
 - b. What type of work is done?

Solution:

Problem 2: Given: A test reveals that 150 ft·lb of work is required to lift an object 3 ft at a **constant speed**.

Find: The weight of the object.

Solution:

- Problem 3:** Given: To tighten a nut, a force of 50 lb is applied at the end of an 18-inch torque wrench. The wrench moves the nut through one revolution (2π radians) on the bolt.
Find: a. The torque generated or applied.
b. The work done on the nut.
Solution:
- Problem 4:** Given: A torque of 300 lb·ft is applied to a lever. The lever does 400 ft·lb of work in lifting a stone.
Find: The angle (in radians) the lever moves through.
Solution:
- Problem 5:** Given: A block and tackle requires 1400 ft·lb of input work to accomplish 1200 ft·lb of output work while lifting a 600-lb load.
Find: The % efficiency of the block and tackle.
Solution:
- Problem 6:** Given: To lift a transformer straight up from the floor to a truck bed located 130 cm above the floor requires 180 joules of work.
Find: The weight of the transformer.
Solution:
- Problem 7:** Given: Bill Johnston and Tim Brown have to push 5 boxes each (with a force of 20 lb on each box) to move the ten boxes from a packing table to a conveyor, a horizontal distance of 10 ft. Bill moves two boxes, goes to the water fountain, returns and moves the other three. Tim Brown moves his 5 boxes in 5 minutes without stopping for a drink.
Find: a. The work done by each person.
b. Who did more work in moving the boxes?
Solution:
- Problem 8:** Given: An auto jack that's considered frictionless raises an auto. The input work on the jack is 3000 ft·lb. The output work on the auto is 3000 ft·lb.
Find: The % efficiency of the jack. (Is this answer reasonable?)
Solution:

Student Challenge

- Problem 9:** Given: A 196-N force is applied to the end of a torque wrench. The arm of the torque wrench is 18 inches long. It causes the wrench to move through an angle of $\pi/4$ radians.
Find: The work done by the applied force in **joules**.
Solution:
- Problem 10:** Given: A heavy spinning flywheel has a radius of 1 meter. It requires 600 joules of energy (work) to bring it to a stop in 1 revolution.
Find: a. The braking **torque** applied to the flywheel (in newton-meters).
b. The braking **force** required to stop the flywheel in one revolution (in newtons).
Solution: