Lab 1 Interference, Diffraction & Polarization of Microwaves

EECS 4614 Electro-Optics

Fall 2025

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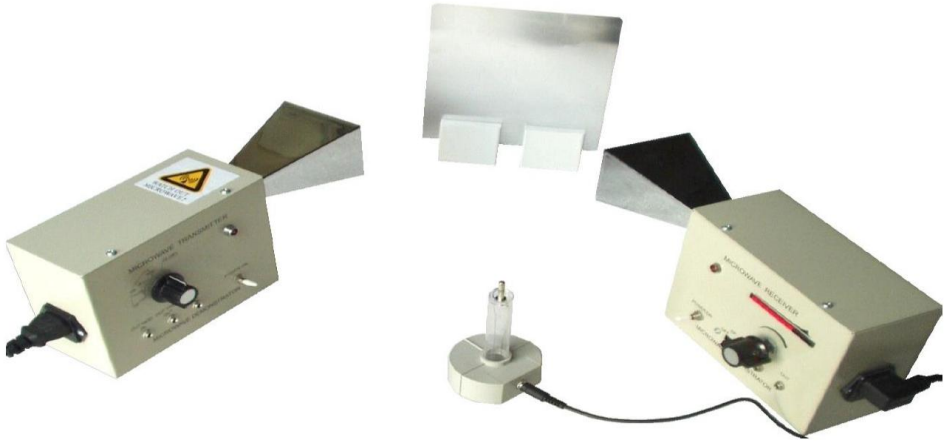


1 Safety

When the microwave transmitter is powered on, 1) do not point the horn antenna of the transmitter to anyone; 2) do not look into the horn antenna as otherwise eye damage could occur; 3) maintain a distance of at least 0.5 m from the transmitter.

Persons with pacemakers are restricted from using this equipment unless approved by the RSO.

2 Introduction

The apparatus for this lab consists of a microwave transmitter and a microwave receiver with amplifier together with receiving dipole and accessories. It can be used to conduct many interesting microwave experiments to observe interference, diffraction and polarization of microwaves. These experiments will demonstrate the same concepts that we study for light with electromagnetic waves of much longer wavelength.

Acknowledgement: This lab handout is based on the equipment instruction manual provided by Lambda Scientific.

3 Evaluation

Log onto eClass and open the assessment for this lab. You will need to show that you can reproduce **all** processes described in the manual and collect/analyze data as directed. This part of the assessment is for the group. Other parts of the assessment will be answering questions about the experiments. These questions are to be answered individually.

4 Equipment

4.1 List of parts

- Microwave transmitter 1 set
- Microwave receiver with amplifier 1 set
- Receiving dipole 1 set
- Cable 2 sets
- Large metal plate (170 mm × 150 mm) 2 pcs
- Small metal plate (170 mm × 50 mm) 1 pc
- Paraffin prism 1 pc
- Board for refraction (150 mm × 80 mm × 40 mm) 1 pc
- Board for absorption (150 mm × 80 mm × 20 mm) 1 pc
- Shelves 4 pcs

4.2 Specifications

1) Microwave transmitter

Operating frequency	11 ± 1.1 GHz
Output power	≥ 10 mW
Signal of internal modulation 3 modes:	monotone, diphone, and music
Signal of external modulation	≥ 1Vpp
2) Microwave receiver with amplifier	
Gain of amplifier	≥ 60 dB
Receiving distance:	
Ten luminous tubes to be lit	≥ 1 m
Speaker to be heard	≥ 3 m

5 Preparation

5.1 Microwave transmitter

Plug a power cord to the microwave transmitter and power it on, after a short warm-up period, the microwave transmitter emits microwave through its horn antenna. When the transmitter is operated under AM modulation, the receiving signal can be heard through the speaker of the receiver; when the transmitter is operated under EQ AMPL (equal amplitude) mode, the receiving signal is indicated by ten luminous tubes (LEDs). External modulation signal can be input from the terminal OUT MOD IN (place the mode selection switch to “out mod”. Modulation signal can be monitored by connecting a speaker to the terminal TO SP using a 3.5 mm earphone plug.

5.2 Microwave receiver

The microwave emitted from the microwave transmitter is detected by the microwave receiver with amplifier, or by the receiving dipole. If the receiving dipole is used, connect the output of the receiving dipole to the input (IN) of the receiver with amplifier using the cable (L=1.5 m) provided, as shown in Figure 1. Optionally, the amplitude of the received signal can be monitored by connecting an oscilloscope to the terminal OUT (using 3.5 mm earphone plug). The dipole antenna can also be directly connected to the oscilloscope.

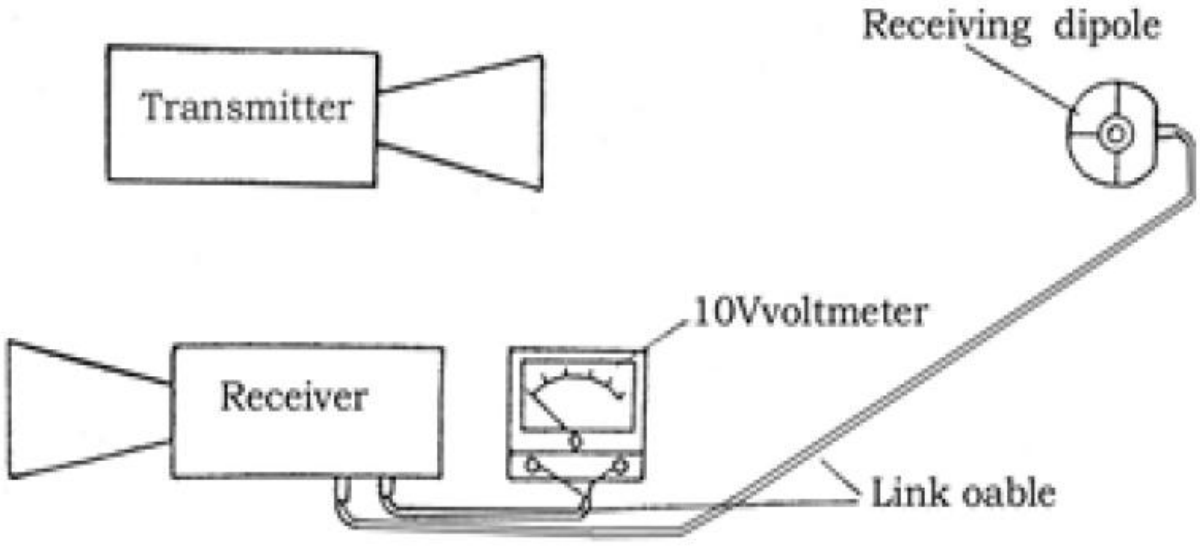


Figure 1 Connection of receiver and receiving dipole

6 Experiments

6.1 Relay of microwave

Place the transmitter and the receiver with amplifier in a line with their horn antennas facing each other. Power the receiver with amplifier on first and then turn the gain knob of the receiver. Now no microwave signal is detected by the receiver, as the transmitter is not turned on yet. Next, power the transmitter on and immediately microwave signal should be detected by the receiver, as the luminous tubes are lit up if under equal amplitude mode or sound is heard from the speaker if under amplitude modulation mode. Experiment with the different controls to become familiar with the operation of the devices (for example: equal amplitude mode, AM modulation, receiver, dipole, oscilloscope connection).

6.2 Transmission and absorption of microwave

Place a metal plate in the middle of the horn antennas of the transmitter and receiver, the microwave signal received by the receiver should be weakened immediately. What happens when you use your hand – why do you observe this?

6.3 Microwave as polarized wave

Since the emitted microwave is polarized and the receiver is polarization sensitive, rotate the horn antenna of the receiver by 90˚ with respect to the horn antenna of the transmitter, no microwave signal should be received by the receiver under this orientation.

MEASUREMENT

By now you will have noticed that the transmitter and receiver have a broad beam width. Using the dipole antenna as a local probe, determine the beam width of the transmitter. The beam width is the angular full width at half maximum of the transmitted wave. You can use the protractor figures at the end of the manual to help yourself with angle measurements.

6.4 Reflection of microwave on a metal plate

Configure the setup as shown in Figure 2. If α=β, then the microwave signal reflected by the metal board can be received by the receiver.

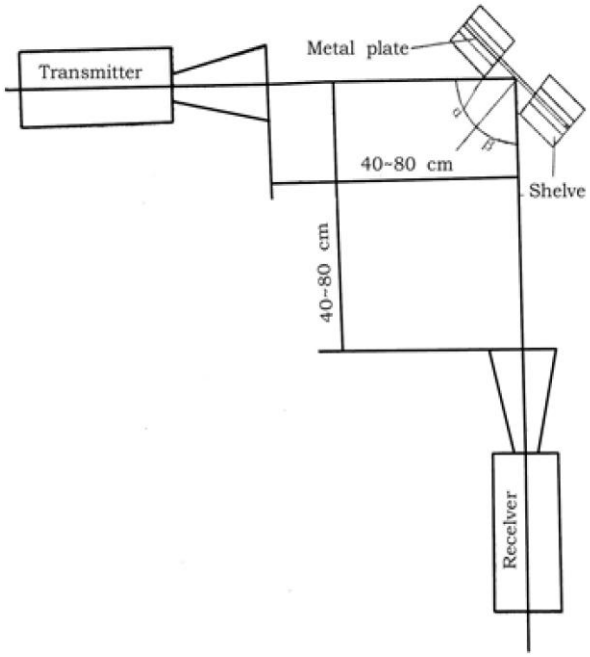


Figure 2 Experimental setup for reflection of microwave on a metal board

6.5 Refraction of microwave

Configure the experimental setup of microwave refraction using a paraffin prism as shown in Figures 3 (a), (b), and (c) and observe whether the prism works as expected. You may need to use metal plates to shield the receiver from waves that do not propagate through the prism but instead directly transmit to the receiver. Do you think the microwaves undergo total internal reflection in Fig. 3 (b)?

MEASUREMENT

Once you are comfortable with properly setting up and understanding sections 6.4 and 6.5, proceed to this measurement. Configure the experimental setup of microwave refraction by a board as shown in Figure 4. Determine the angle that receives the strongest microwave signal as seen in Figure 4. Use Snell's law and your measurements of angles α and β to calculate n of the paraffin prism.

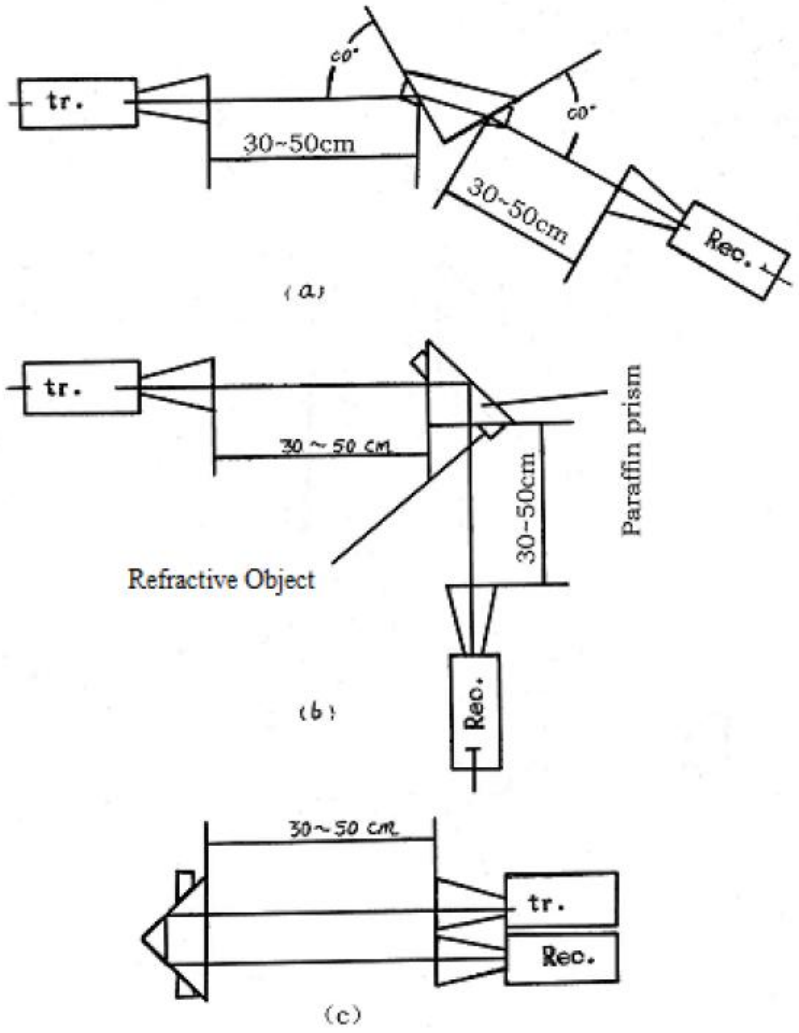


Figure 3 Experimental setup of microwave refraction by a paraffin prism

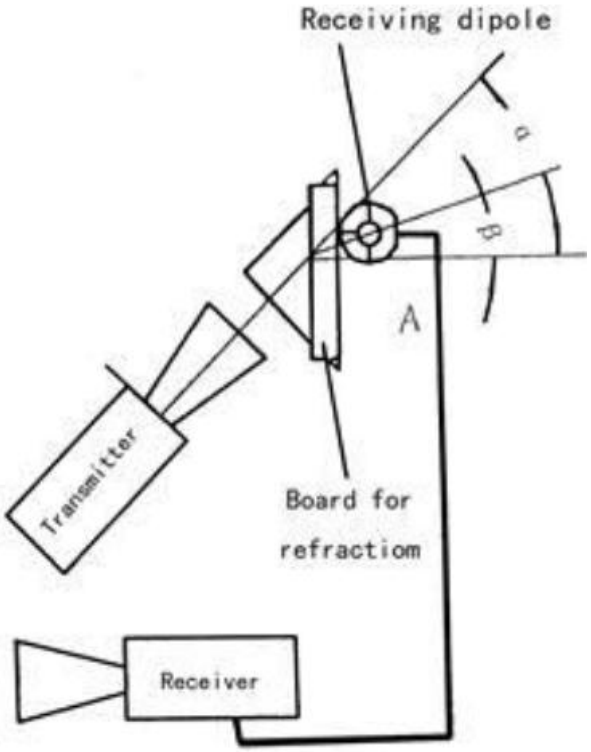


Figure 4 Experimental setup of microwave refraction by a board

6.6 Standing wave formation of microwave

Configure the experimental setup for standing wave formation of microwave as shown in Figure 5. If the receiving dipole is moved along the propagation direction of the microwave, it can be used to verify locations of the maximum and minimum peaks of the standing wave. What is the spacing between them? Compare it to the wavelength.

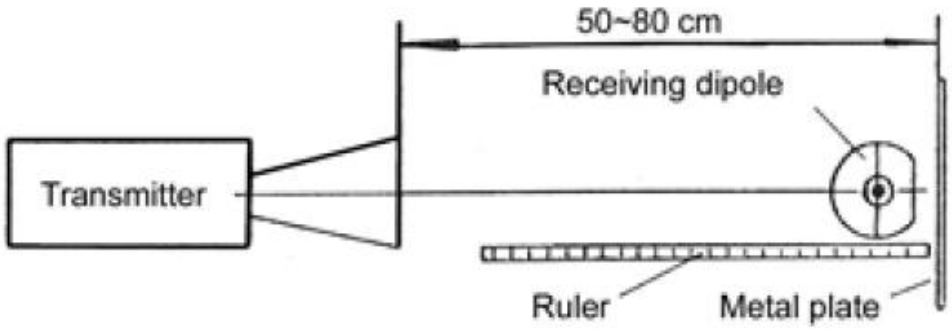


Figure 5 Experimental setup for standing wave formation of microwave

6.7 Diffraction of microwave

Configure the experimental setup for diffraction of microwave as shown in Figure 6. As seen in this figure, microwaves are radiated towards the edge of a metal plate, and the receiving dipole located behind the metal plate still detects the microwave signal proving that microwaves are diffracted at the edge of the metal plate. You may also observe variations of intensity close to the edge.

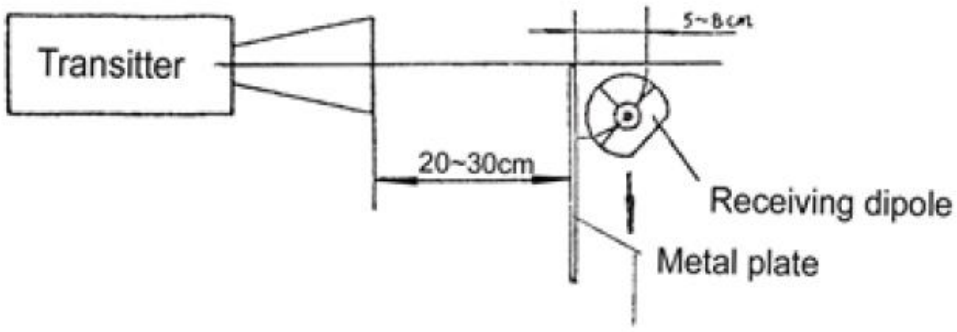


Figure 6 Experimental setup for diffraction of microwave

MEASUREMENT

Configure the experimental setup for microwave diffraction at a single slit as shown in Figure 7. Apart from the strong maximum microwave signal at the central location, there are two weaker maximum peaks of microwave signals located on either side of the central position. Catch these peaks with the receiver. Measure the beam width of the main peak and compare these with the beam width obtained in earlier and the divergence expected using the relation $\Delta\theta = 2\lambda/a$, where a is the slit width. This relation is valid when the distance D between slit and receiver is large. Alternatively, the distance between the minima on either side of the peak is given by $2\lambda D/a$.

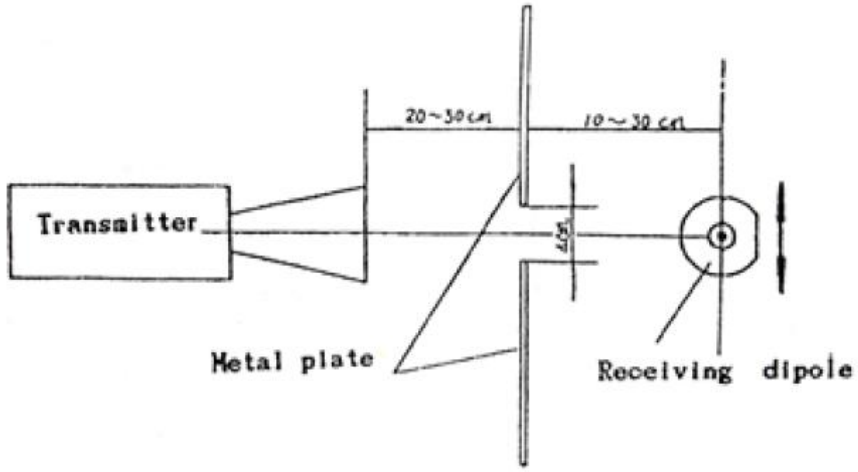


Figure 7 Experimental setup for microwave diffraction at a single slit

Configure the setup for microwave interference due to diffraction at double slits per Figure 8. Observe the peaks behind the slits. Report your results of standing waves and single slit diffraction.

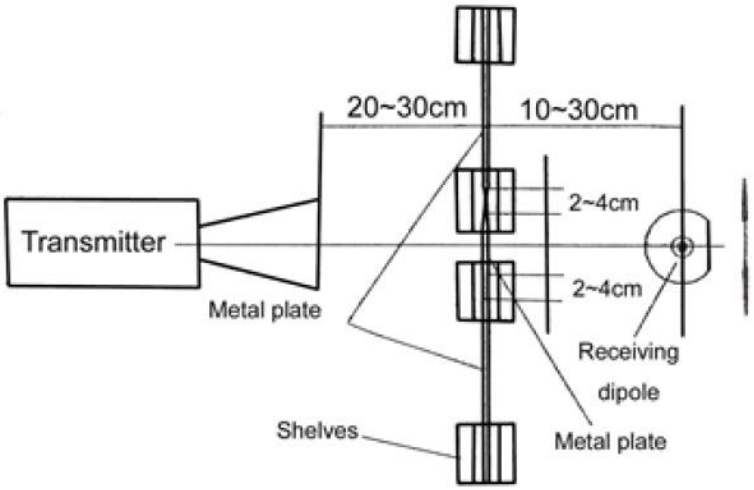
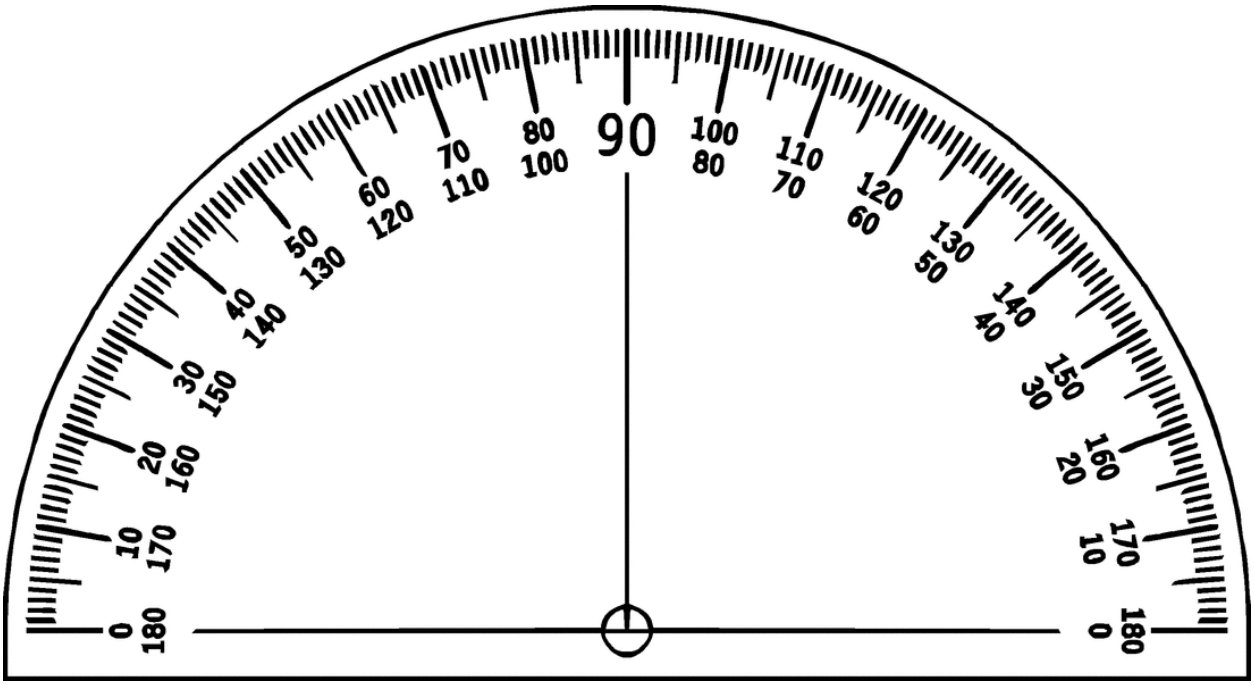


Figure 8 Experimental setup for microwave interference due to diffraction at double slits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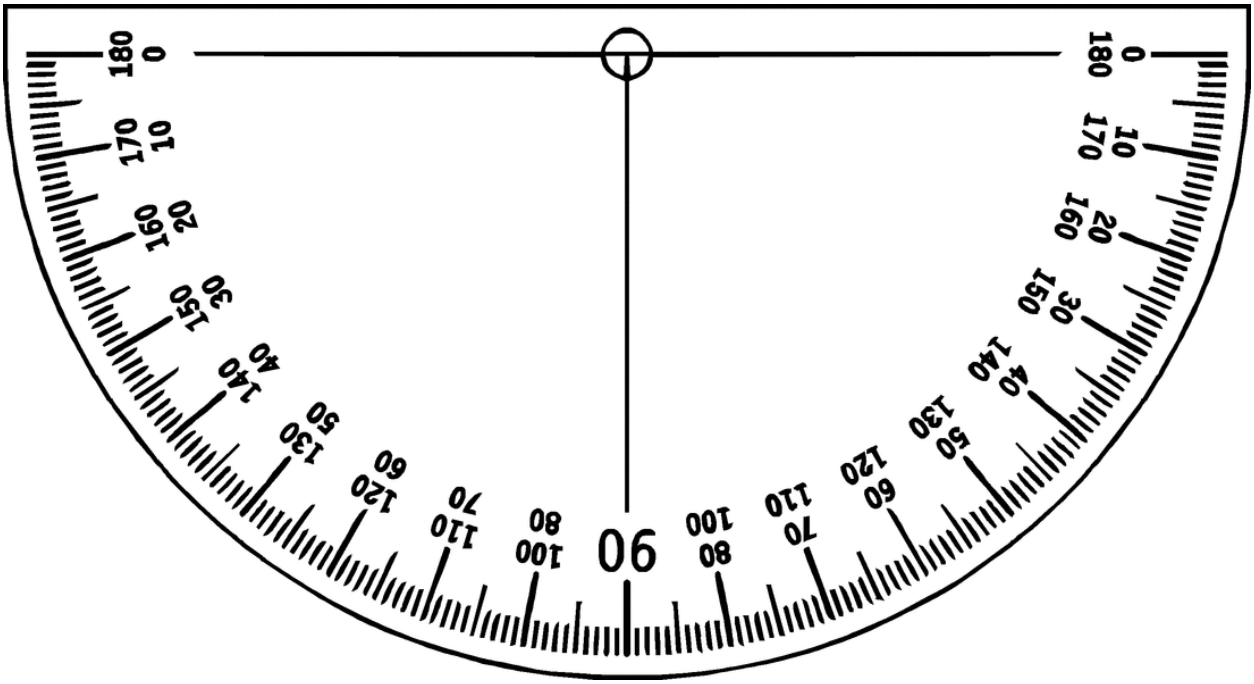
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