Name: ________________________________ Date: ________________ Team: _____

RS 1 Lab Experiment # 4

mAs Reciprocity Law

The Reciprocity Law | The mA and Time Relationship

Direct Radiography Lab

Purpose

This digital (DR) system experiment is designed to demonstrate the effect of mA and exposure time on exposure index and how to maintain exposure index when changing both mA and exposure time while mAs is held constant.

Learning Objectives

After completing this lab, you should be able to:

1. Use the laboratory equipment properly.
2. Set up the control console and ceiling tube mount correctly.
3. Function effectively in group work.
4. Perform the experiment independently.
5. Evaluate the effect of mA and exposure time on exposure index.
6. Calculate the appropriate mA or exposure time to maintain exposure index.
7. Explain the mAs reciprocity law.
8. Summarize the mA and exposure time relationship when maintaining exposure index.
9. Predict the effect of the change in mA or exposure time on exposure index.

Materials Needed

- Flat Panel Detector (FPD)
- Knee phantom
- Set of lead numbers

Pre-Lab Discussion

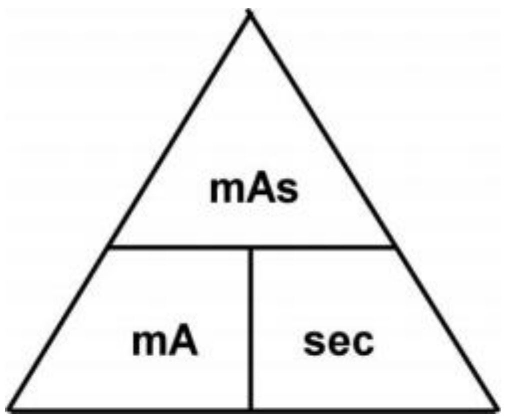
- Image brightness is the overall level of light emitted by an electronic image.

Radiographers have many methods at their disposal to control the exposure index of a radiographic image. Of all the primary exposure factors, **the exposure factor manipulated most often is mAs**. The mAs are the product of the milliamperage and exposure time.

To determine the missing exposure factor you will need to apply the following radiologic science formula:

$$\text{mA} \times \text{second} = \text{mAs}$$

The shortcut for remembering how to rearrange this formula to find an unknown variable is:



To use this shortcut:

Place your thumb over the unknown (what you want to find); what remains uncovered is the variation of the formula necessary to calculate the unknown.

Radiographically:

An INCREASE in mA will **INCREASE** EXPOSURE INDEX.

An INCREASE in exposure time will **INCREASE** EXPOSURE INDEX.

An INCREASE in mAs will **INCREASE** EXPOSURE INDEX.

mAs Reciprocity Law

The reciprocity law is used to <u>maintain</u> image density.

If the mAs are held constant, the change in mA is <u>inversely proportional</u> to the change in exposure time when maintaining image density.

The exposure index is **<u>directly proportional</u>** to the mAs used; so, if an equivalent mAs is used (mAs is held constant) to produce a second radiograph of the same object, the density will be the same. Put simply, any combination of mA and time that results in the same mAs will produce the same exposure index on the radiograph.

Therefore, mA and time are **<u>inversely proportional</u>** to each other when maintaining exposure index.

Consequently, if you increase one, you must decrease the other proportionately to maintain the same mAs, radiation exposure and exposure index.

Symbolically:

$$\uparrow \left\| \quad \frac{\text{second}_{new}}{\text{second}_{old}} = \frac{\text{mA}_{old}}{\text{mA}_{new}} \quad \right\| \downarrow$$

(When mAs is held constant)

Radiographically:

MAINTAINING the same mAs will MAINTAIN exposure index.

Hostos Radiography Lab Practices

When working in the radiography lab at Hostos, all your images must be properly identified using ***x-ray beam attenuating markers***. The following information must be visualized on the image and demonstrate accurate placement:

1. A lead examination room letter. **A, B or C** (patient ID)
2. A lead anatomical side marker. **L or R** (exam data)
3. A lead experiment exposure number. **1, 2, 3, etc** (exam data)

Practice Drill No. 3 – mAs Reciprocity Law

1. An exposure requires 100 mA and 0.2 seconds.
   What would the **new exposure time** be if 400 mA were substituted?

Solve using the formula:	***Illustrated Thought Process:***	
	The **mA** (□/□)	_____________
	by a factor of	_____________
	Relationship:	_____________
	So, the **time** (□/□)	_____________
	by a factor of	_____________

New exposure time:

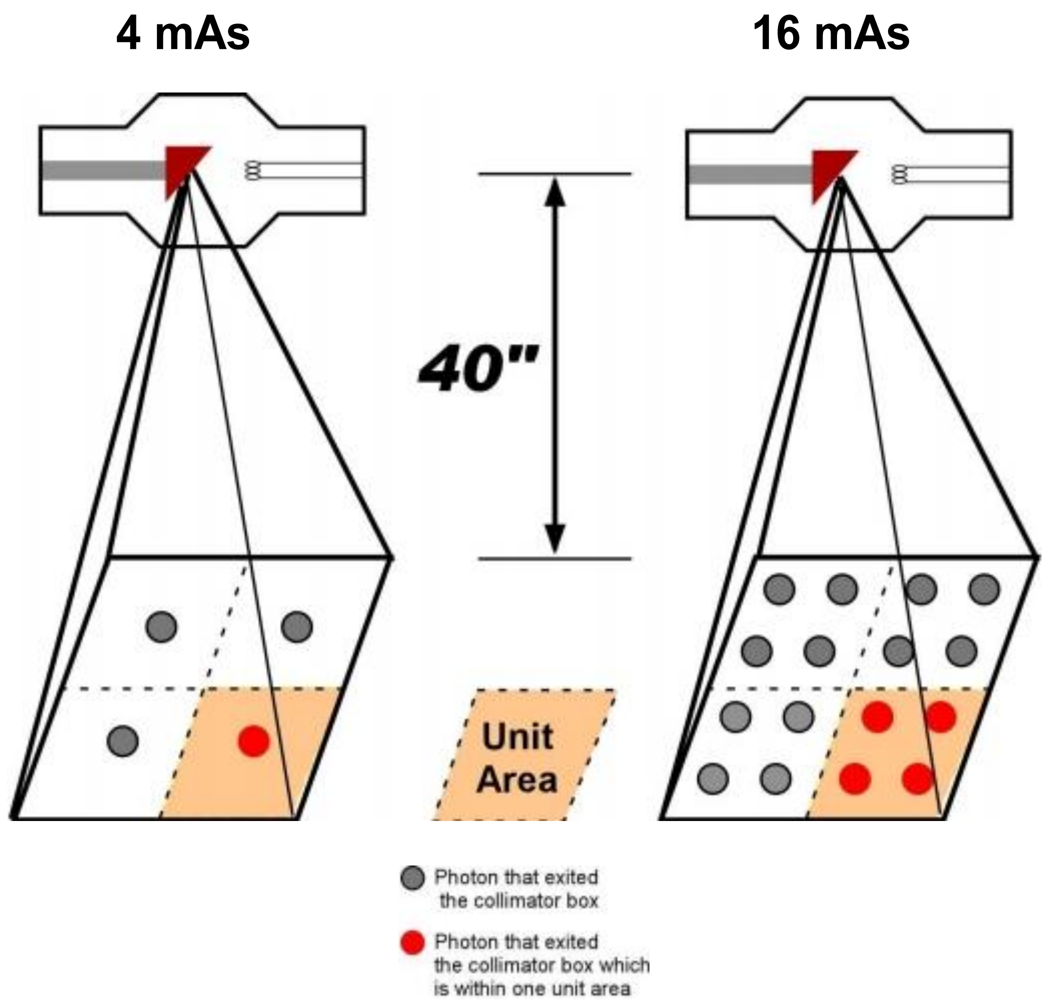
2. An exposure requires 100 mA and 0.75 seconds.
   What would the **new mA** be if 0.25 s were substituted?

Solve using the formula:	***Illustrated Thought Process:***	
	The **time** (□/□)	_____________
	by a factor of	_____________
	Relationship:	_____________
	So, the **mA** (□/□)	_____________
	by a factor of	_____________

New mA:

Remember, to "increase by a factor of" means multiply; to "decrease by a factor of" means divide.

Effect of mAs on Exposure

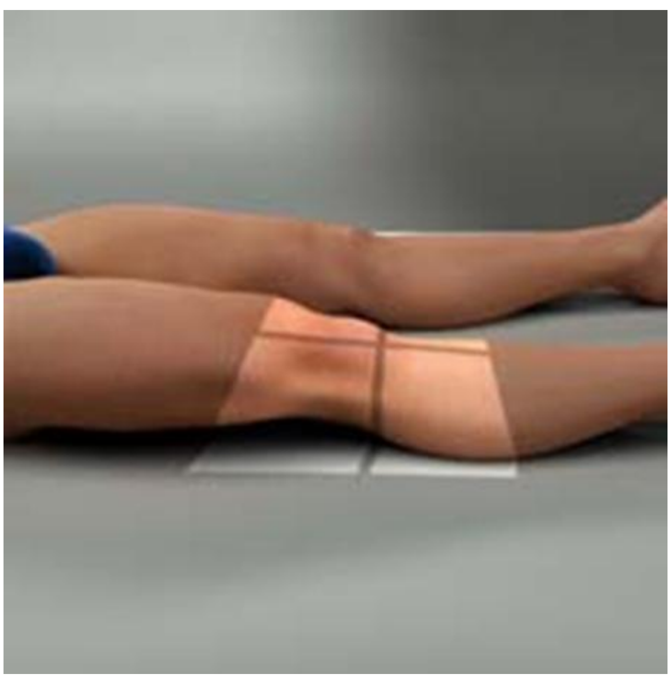


Experimental Procedure

Instructions for all the Exposures

1. Place the IR on the tabletop and set the SID to 40 inches (100 cm).
2. Place the **Knee** phantom in the center of the image receptor in the supine position for AP projection.
3. Direct the central ray **perpendicular** through the **center of the part and the image receptor**.
4. Tape the x-ray beam attenuating (lead) markers onto the image receptor and collimate the x-ray beam to the appropriate size.
5. Set the x-ray tube, **manual TT** mode of operation and radiographic technique (kVp, mA, time) as indicated in the technique worksheet. Using the **Technique Chart**, determine the optimal mAs for the study.
6. Evaluate exposure index (EI) for exposure 1.

7. Use the same mAs for exposures 1 through 5 if the EI is optimal. Determine different combinations of mA and time that would produce the desired mAs and the optimal EI for exposures 1 through 5



The Exposure Index (EI) can be used to confirm that the exposure at the detector is at the proper level to produce acceptable image quality, as established by the radiology department.

The Exposure Index provides feedback to the operator so that the exposure consistency can be monitored and excessive under or over exposure prevented.

Exposure Index – EI

- Exposure index is linear in relation to detector dose
- As exposure to the image receptor (IR) increases, the Exposure Index increases

Technique Worksheet

(AP Knee – Tabletop TT)

Manual Mode

Technical Factors for Room A, B, C, and D

	mA	Time	mAs	kVp	Image Receptor	Focal Spot	SID	EI/DAP
		Sec/ms				Small or large	inches	
1	50		2	80	DR		40	
2	100		2	80	DR		40	
3	200		2	80	DR		40	
4	400		2	80	DR		40	
5	500		2	80	DR		40	

For exposures 1-5, use different combinations of mA and time to aim for a total of 2 mAs for each exposure. If achieving exactly 2 mAs is not possible, select the closest mAs value available. Calculate the mAs by multiplying the chosen mA by the corresponding time in seconds. Keep in mind that mA values may vary between rooms A, B, C, and D, so adjust the settings accordingly. Record the combinations used for each exposure and ensure they are as close to 2 mAs as possible.

Remember that the **mAs value directly impacts patient exposure**—higher mAs increases the radiation dose to the patient, while lower mAs reduces it. Additionally, the **exposure index (EI)** will vary based on the mAs used; higher mAs results in a higher EI, indicating a greater signal reaching the detector, while lower mAs will produce a lower EI, which could affect image quality.

Lab 3

Calculations:

Lab Analysis Worksheet

	EI	Compare EIs of exposures 1-5. Are they completely different or are they similar? Which technique generates the highest patient exposure Why?
1-5		