Name: ________________________________ Date: ________________ Team: _____

Lab Experiment # 3

mAs Reciprocity Law

The Reciprocity Law | The mA and Time Relationship

Computed Radiography Lab

Purpose

This digital (CR) 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 and DAP.

Materials Needed

- 10" x 12" IR
- Hand phantom
- Set of lead markers and numbers

Pre-Lab Discussion

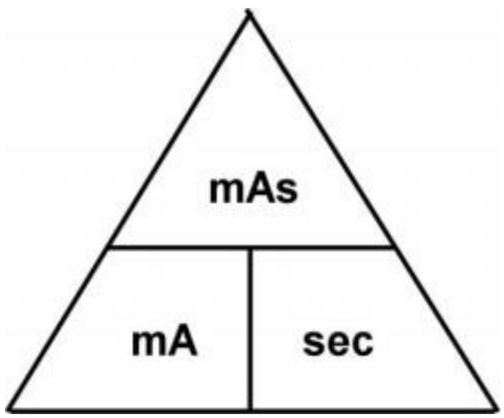
- Image brightness is the overall level of light emitted by an electronic image.

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:

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

(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 <u>100 mA</u> and <u>0.2 seconds</u>.
   What would the **<u>new exposure time</u>** be if <u>400 mA</u> were substituted?

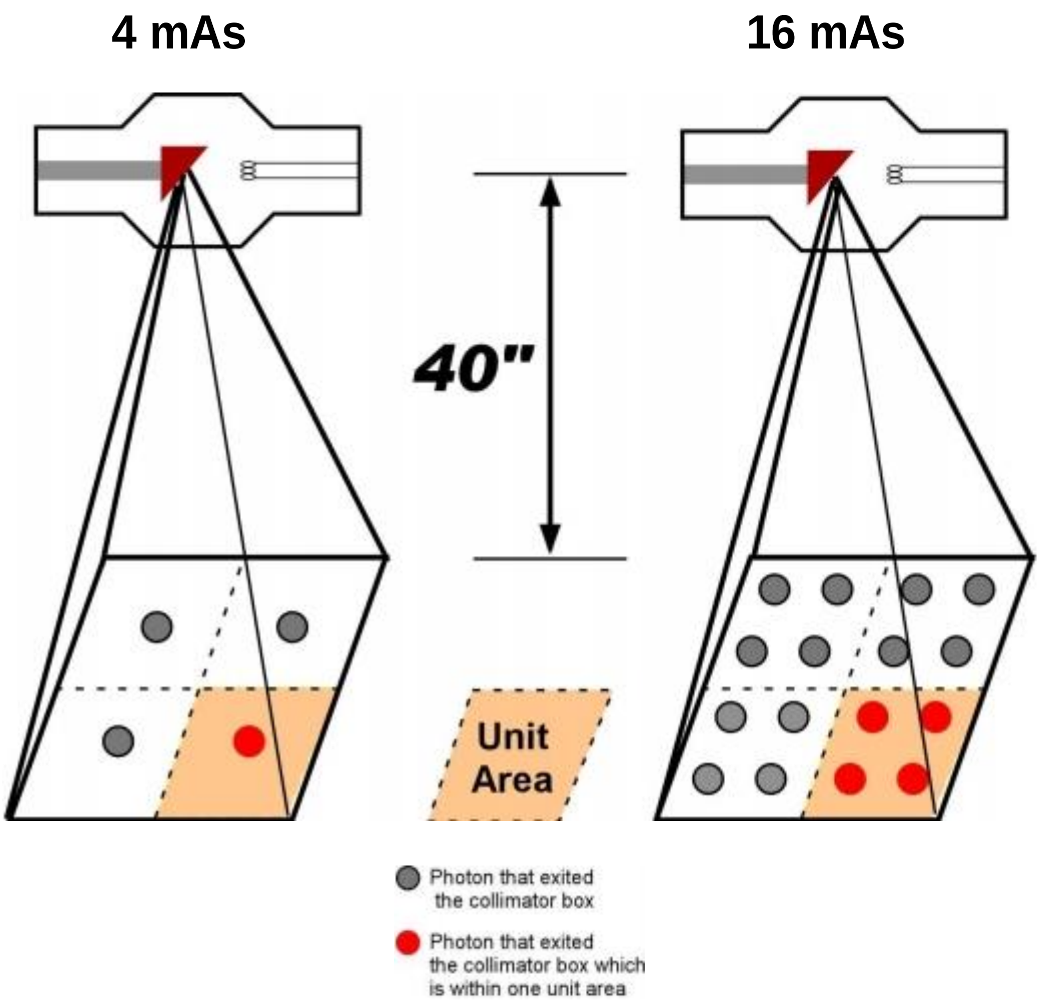
Solve using the formula:	***Illustrated Thought Process:***
	The **mA** (increased/decreased) ____________ by a factor of ____________ Relationship: ____________ So, the **time** (increased/decreased) ____________ by a factor of ____________
	New exposure time:

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

Solve using the formula:	***Illustrated Thought Process:***
	The **time** (increased/decreased) ____________ by a factor of ____________ Relationship: ____________ So, the **mA** (increased/decreased) ____________ by a factor of ____________
	New mA:

Remember, to "increase by a factor of" means <u>multiply</u>; to "decrease by a factor of" means <u>divide</u>.

Effect of mAs on Exposure



Experimental Procedure

Instructions for all the Exposures

1. Place a 10 x 12 inch image receptor on the tabletop and set the SID to 40 inches.
2. Place the hand phantom in the center of the image receptor in the prone position for PA 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 beam to the size of the **image receptor**.
   (The room, anatomical side, and exposure number must be labeled on **ALL** images.)
5. Set the x-ray tube, mode of operation and as indicated in the technique worksheet.
6. Expose film number 1 using the settings indicated in the technique worksheet.
7. Process the image receptor.
8. Repeat steps 1 through 7 for exposures 2, 3, 4, 5, and 6.
9. Expose IR 2, 3, 4, 5, and 6 using the settings indicated in the technique worksheet.

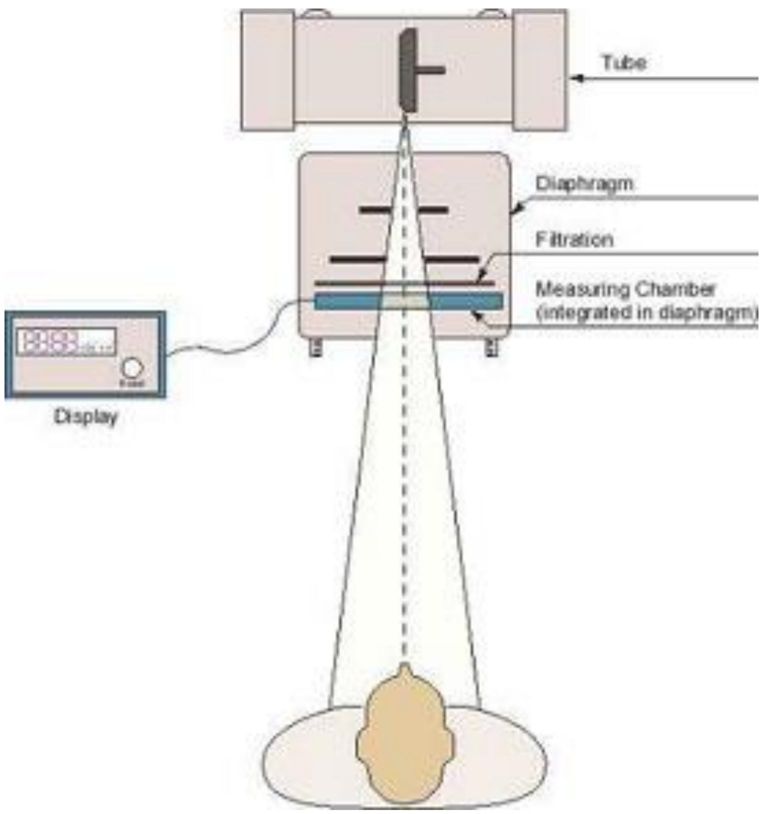
The term for exposure indicator in an Agfa (Mortsel, Belgium) system is the logarithm of the median exposure (lgM).

An exposure of 20µGy at 75kVp with copper filtration yields a lgM number of 2.6. Each step of 0.3 above or below 2.6 equals an exposure factor of 2.

	Overexposure	Underexposure	Adult: Nongrid and Grid	Distal Extremities Nongrid
Agfa (Lgm)	>2.9	<2.1	2.1–2.3	2.4–2.6

Dose area product (DAP) is a quantity used in assessing the radiation risk from diagnostic X-ray examinations and interventional procedures.

DAP-meters measure the product of radiation dose to air and the area of the X-ray field. DAP is expressed in cGy.cm^2 or mGy cm^2. An ionization chamber larger than the area of the X-ray beam is placed just under the X ray collimators. The DAP ionization chamber must intercept the entire X-ray field for an accurate reading. The reading from a DAP-meter can be changed by either altering the X-ray technique factors (kVp, mAs or time), or varying the area of the field or both.



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Technique Worksheet

(PA HAND – Tabletop TT)

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

	mA	Time	mAs	kVp	Image Receptor	Focal Spot	SID	LGM	DAP
		sec or ms				Small or large	inches		$cGy\ cm^2$
1	50		4	64	CR		40		
2	200		4	64	CR		40		
3	400		4	64	CR		40		
4	50		4	64	CR		40		
5	200		2	64	CR		40		
6	400		8	64	CR		40		

Worksheet

1. Which exposures produce similar LGMs and why?
2. Which exposures produce similar DAPs and why?
3. Which exposure produce the highest LGM and why?
4. Which exposure produce the lowest LGM and why?
5. Which exposure produce the highest DAP and why?
6. Which exposure produce the lowest DAP band why?