# Chapter 7

## PRINCIPLES OF EXPOSURE AND IMAGE QUALITY

# Learning Objectives

- List the prime factors of exposure
- State the formula for determining milliampere-seconds (mAs) and explain how this unit is useful to the radiographer
- Explain the radiographic effect of the four prime factors of exposure
- Define radiographic distortion and explain the difference between magnification and shape distortion

# Learning Objectives

- Recognize changes in radiographic density and state the exposure factors used to control radiographic density
- Identify high, low, and optimum contrast on a radiograph and state the exposure factor that primarily controls radiographic contrast

# Learning Objectives

- Define *spatial resolution* or *recorded detail* and list factors that influence it
- List and explain the geometric factors that affect recorded detail and explain why magnification affects detail
- List and discuss methods for minimizing motion blur on radiographs

# Prime Factors of Radiographic Exposure

- The prime factors affecting radiographic exposure include
  - Milliamperage (mA)
  - Exposure time (s)
  - Kilovoltage (kVp)
  - SID (source-image receptor distance)

# Prime Radiographic Exposure Factors

- Milliamperage (mA)
  - Affects the exposure rate or number of x-ray photons produced per second
  - Exposure is directly proportional to mA
    - Doubling mA results in a doubling of the number of electrons used to produce the x-ray beam
    - Halving mA results in a halving of the number of electrons used to produce the x-ray beam

# Prime Radiographic Exposure Factors

- Exposure Time
  - Controls how long the exposure lasts
  - Exposure is directly proportional to the exposure time
    - Doubling or halving exposure time results in a doubling or halving of the number of electrons used to produce the x-ray beam respectively

# Prime Radiographic Exposure Factors

- Milliampere-seconds (mAs)
  - Indicates total number of x-rays in an exposure
  - Exposure and patient dose are directly proportional to mAs
  - Product of mA and time
  - Primary controlling factor of density

$$mA \times time = mAs$$

$$200\ mA \times 0.05\ seconds = 10\ mAs$$

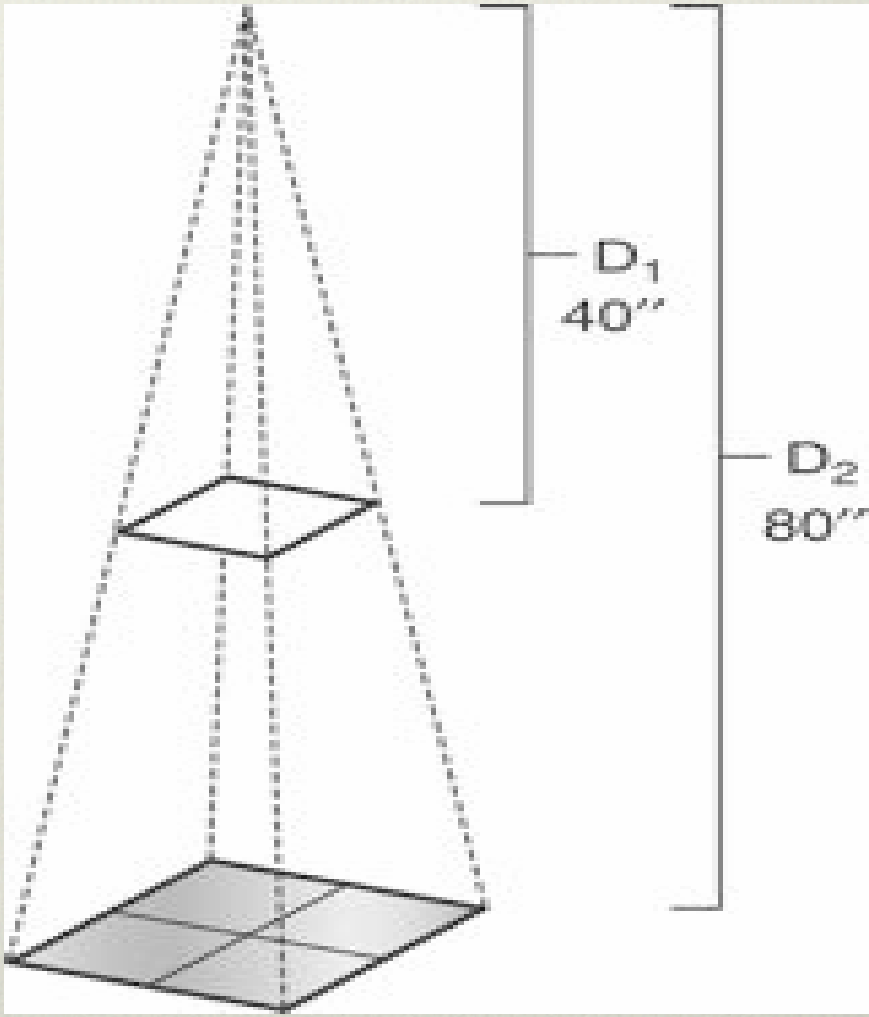
# Prime Radiographic Exposure Factors

- Kilovoltage (kVp)
  - Controls the wavelength and energy of the x-ray beam
  - Controls the power and speed of the electrons in the tube current
  - Energy is related to the ability of the x-rays to penetrate the patient and reach the IR
  - The primary controlling factor of penetration and contrast

    * Increasing or decreasing kVp increases or decreases the wavelength, energy, and penetration of the x-ray beam respectively, but not in direct proportion

# Prime Radiographic Exposure Factors

- Source Image Receptor Distance (SID)
  - X-rays diverge or spread as they exit the tube
  - Amount of divergence depends on length of the SID and affects the intensity of the x-ray beam



# Prime Radiographic Exposure Factors

- The inverse square law states that radiation intensity is inversely proportional to the square of the distance

$$\frac{I_1}{I_2} = \frac{(D_2)^2}{(D_1)^2}$$

$I_1$ = Original Intensity
$I_2$ = New Intensity
$D_1$ = Original SID
$D_2$ = New SID

# Question

If the radiation intensity at 30″ is 10 mR, what will the intensity be at 60″?

a) 40 mR

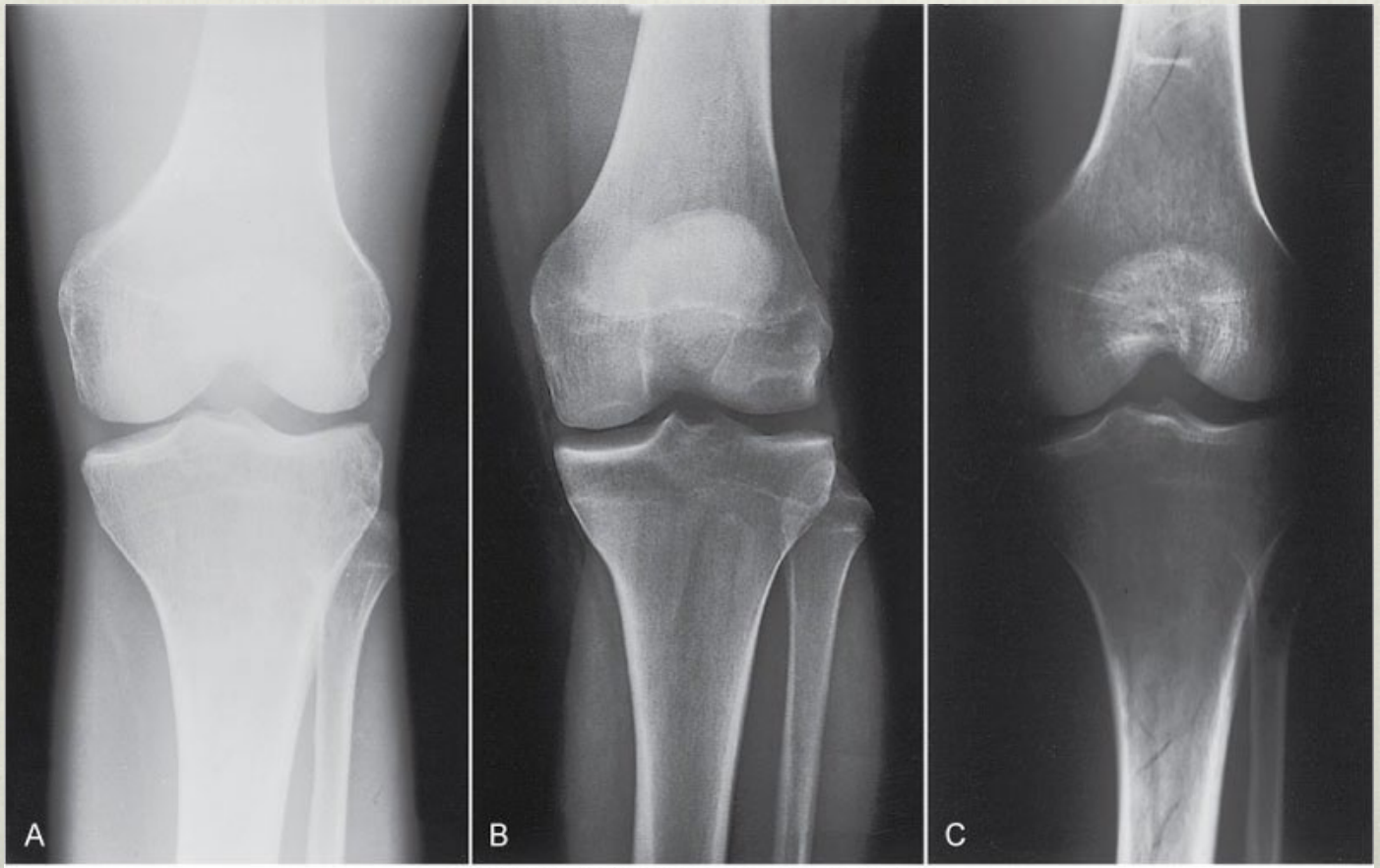
b) 20 mR

c) 5 mR

d) 2.5 mR

# Radiographic Quality Factors

- Density or overall blackness of the radiograph
  - Affects visibility of image detail
  - Is primarily controlled by mAs (although kVp and SID also influence density)



# Radiographic Quality Factors

- Contrast or difference in density between adjacent areas of the image
  - Visibility of detail is affected
  - kVp is primary controller
  - Subject contrast (tissue density) is the variation in beam intensity after it passes through the patient
  - Radiographic contrast is the combination of IR and subject contrast
  - Fog from scatter radiation or image processing can reduce contrast


Long scale (low contrast)

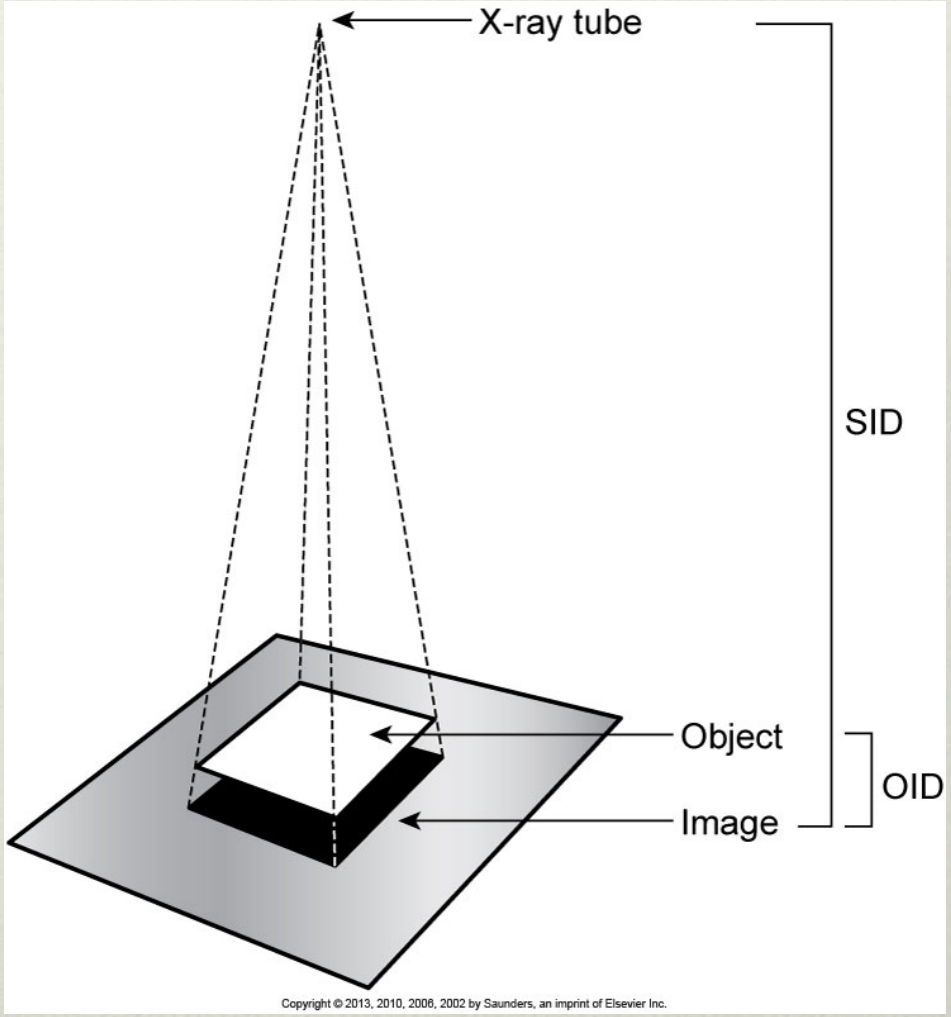
Short scale (high contast)

# Radiographic Quality Factors

- Contrast
  - Optimal contrast may be high or low depending on the composition of the body part
  - Low contrast = less difference between densities
  - High contrast = greater difference between densities

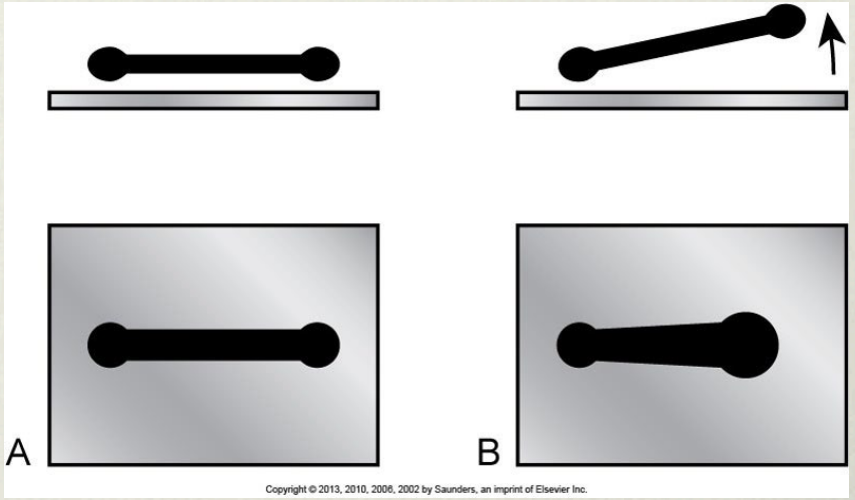
# Radiographic Quality Factors

- Size Distortion or Magnification
  - Anatomic part appears larger than it actually is
  - Affected by
    - SID - greater
    - OID - minimal

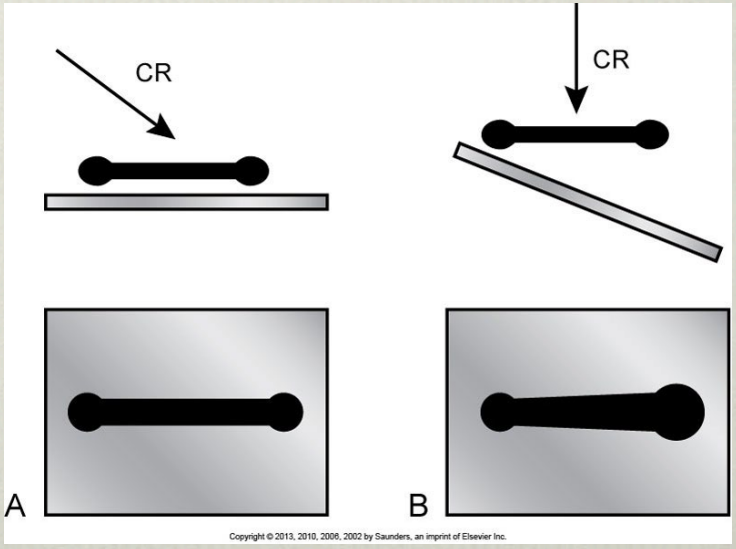


# Radiographic Quality Factors

- Shape Distortion or Unequal Magnification
  - Length or shape of anatomy is misrepresented
  - May be caused when body part is not parallel to the IR or when the CR is angled







# Spatial Resolution/Recorded Detail

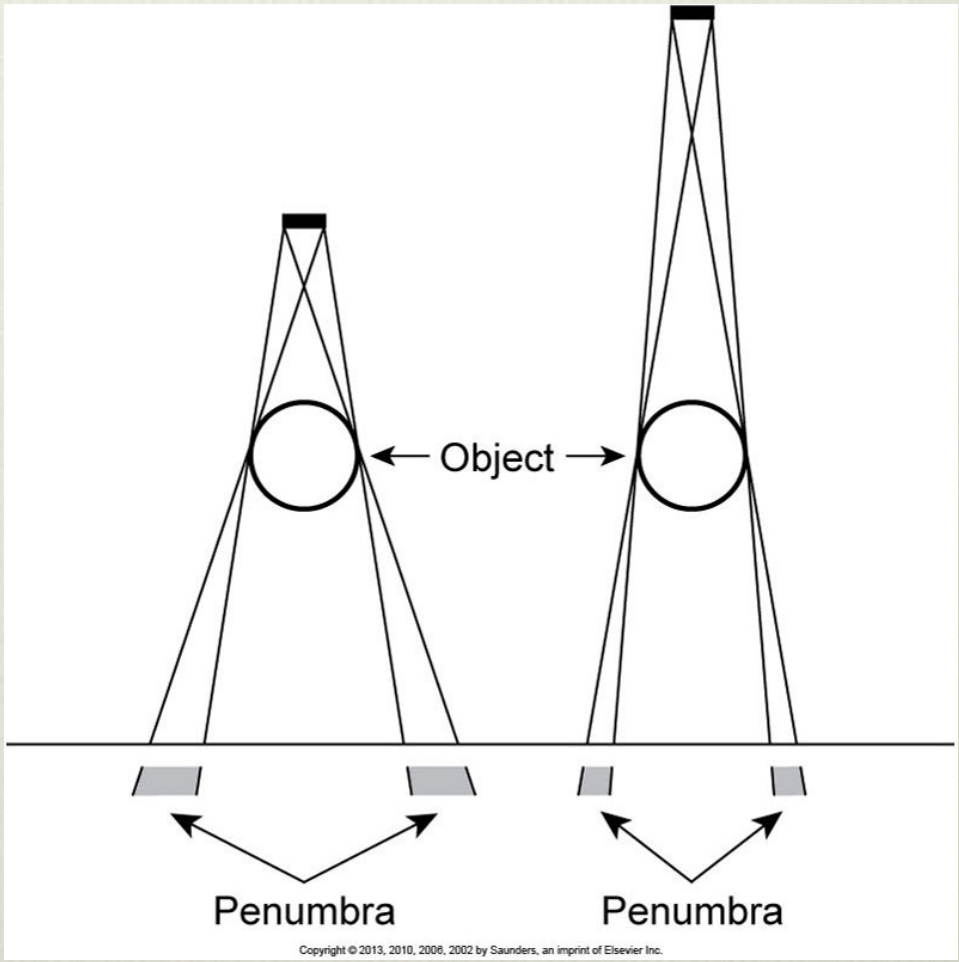
- Refers to image clarity
- Affected by
  - Motion – can be avoided by using a short exposure time/educating patient
  - Quantum mottle –grainy or mottled (spotty) due to mAs or kVp set too low
  - Focal spot size – small focal spot for greater detail
  - OID/SID – decrease OID for greater detail/increase SID for greater detail
- Also referred to as *resolution, sharpness, definition,* or *detail*

# Factors Affecting Image Detail

- Factors which control formation of image
  - SID
  - OID
  - Focal spot size
- Use factors to reduce penumbra (unsharp edges) or image blur

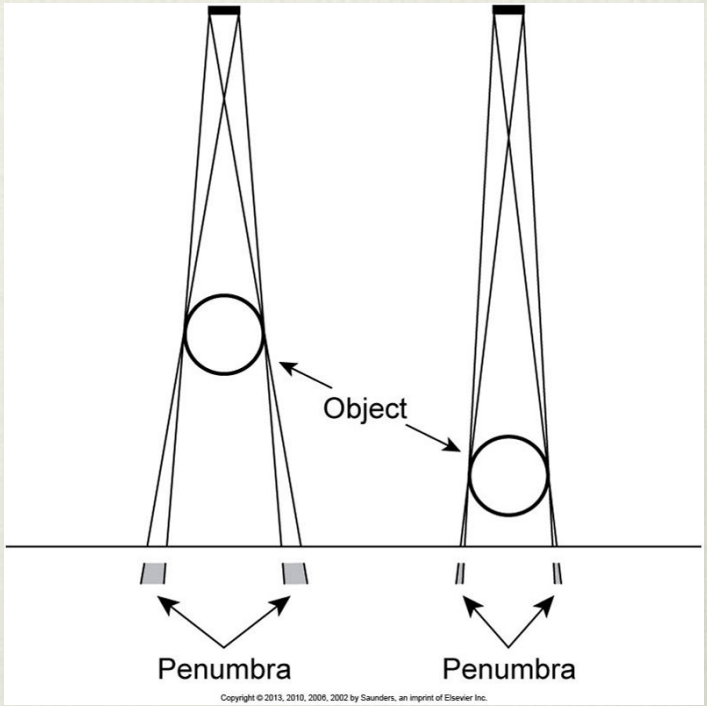
# Factors Affecting Image Detail

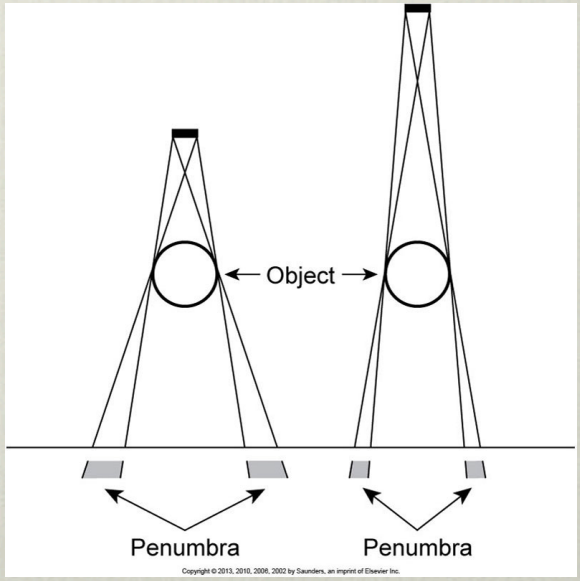
- Focal Spot Size
  - Small focal spots produce less penumbra, resulting in a sharper image



# Factors

- OID
  - Reducing the distance between the object and IR decreases penumbra
- SID
  - Increasing the distance between the radiation source and IR decreases penumbra
- Use the shortest OID and longest SID practical



# Other Factors Affecting Image Detail

- Motion
  - Movement of the patient, IR, and x-ray tube will cause blurring
  - Can be voluntary (normally controllable) or involuntary (tremors, heartbeat, peristalsis)
  - Effective communication is a key factor in avoiding motion in the image
  - Principal means of controlling motion is to use a short exposure time

# Summary

- The prime exposure factors are milliamperage, exposure time, kVp, and SID
- The prime exposure factors are manipulated to control the radiographic quality factors: density, contrast, and distortion

# Summary

- *Spacital Resolution/Recorded detail* refers to the image clarity
- *Penumbra* is the inherent blurriness in the radiographic image
- Penumbra may be reduced and image sharpness increased by using the appropriate SID, OID, and focal spot size
- Image sharpness may also be affected by motion, intensifying screen speed, and film/screen contact