Course › Section... › 1.7 Su... › 1.7.1 S...

1.7.1 Summary Quiz Part 1

Bookmark this page

These questions are meant for you to reflect upon the basics of the models we learned about in this section.

Question 1

1/1 point (graded)

Let's reflect on the differences and connections between CT scans and x-rays. Which of the following are true?

- [ ] An x-ray image is a two-dimensional image while a CT-scan is a three-dimensional image.
- [ ] An x-ray consists of multiple CT-scans superimposed.
- [ ] A CT-scan consists of multiple x-rays superimposed.
- [x] A CT-scan is created by using multiple x-rays to determine the attenuation value at points in a slice of the body. ✔
- [x] An x-ray is an integral of the attenuation function and a CT-scan is a map of the attenuation function values. ✔
- [ ] A CT-scan is an integral of the attenuation function and an x-ray is a map of the attenuation function values.

Explanation

An x-ray image is a two-dimensional image of all the different 2-dimensional slices of a three-dimensional object superimposed. A CT-scan is a two-dimensional image of a single slice of the three-dimensional object which shows the attenuation of each point in that slice.

Mathematically, each point of an x-ray image comes from computing the ratio of the output intensity to the input intensity and taking the negative natural logarithm. This is called the projection and is equivalent to taking the integral of the attenuation function for that point, though it is not computed by doing the integral explicitly because we don't know the attenuation function ahead of time.

Mathematically, a CT-scan is a map of the attenuation function in a particular slice of the body. It comes from combining information from multiple x-rays taken at different viewpoints around the object and using mathematical methods to determine the attenuation function from this information.

Choice (a) is wrong because both x-rays and CT-scans are two-dimensional images.

Choice (b) is wrong, as CT-scans are created from multiple x-rays, not the other way around.

Choice (c) is wrong. While CT-scans are created from multiple x-rays, it is not by superimposing them. It is by using the information they give to determine the attenuation function.

Choice (e) is wrong - it is the other way around: An x-ray is an integral of the attenuation function and a CT-scan is a map of the attenuation function values.

Submit You have used 2 of 3 attempts

Answers are displayed within the problem

Question 2

2/2 points (graded)

Recall that a projection graph plots the projection value (roughly the amount of light attenuated) as a function of the position along the x-ray source. For each of the graphs, choose any of the two-dimensional objects that could plausibly have that projection graph.

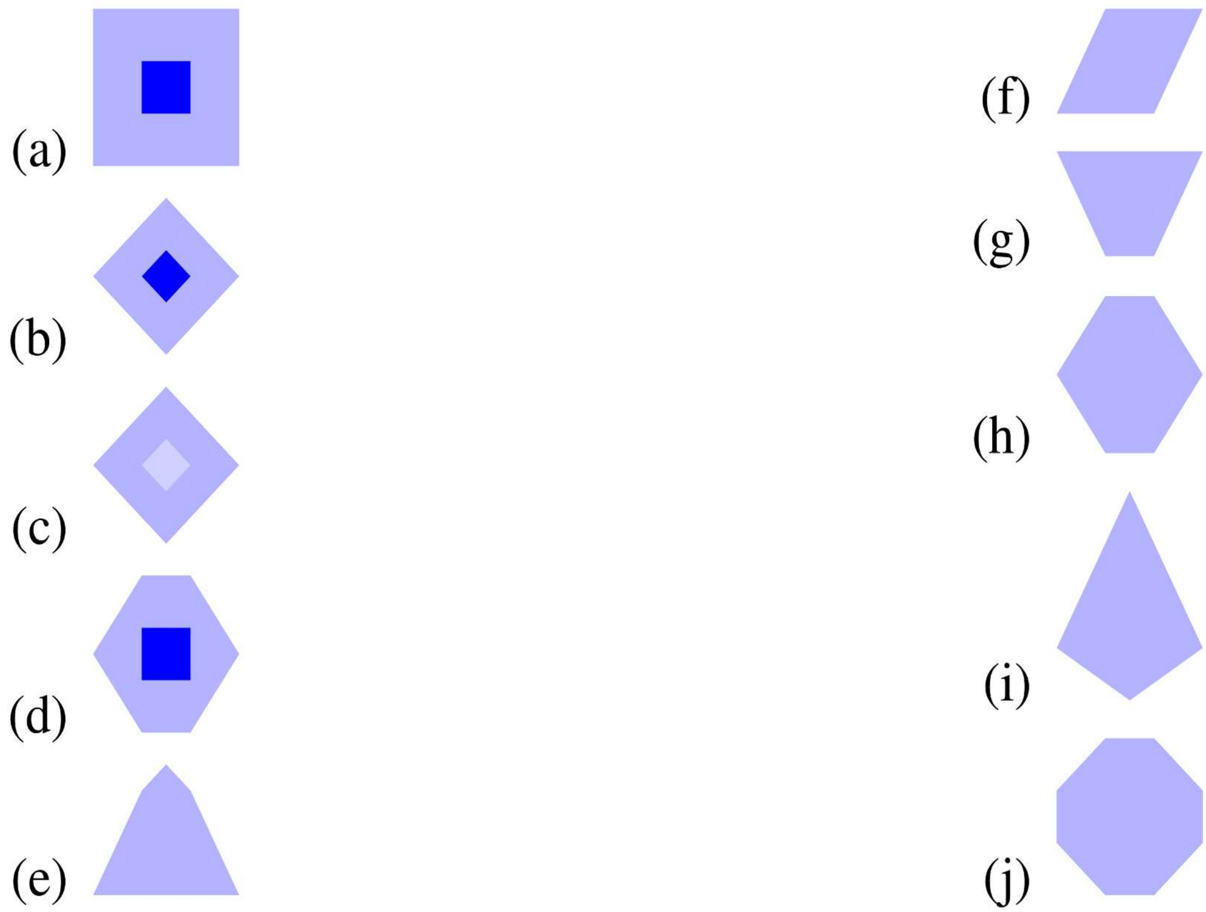
• Assume the x-ray source is positioned below the object and parallel to the horizontal.

• There may be more than one object that matches with a graph. This does not mean the two objects have identical graphs, only that they share similar enough features that we can't distinguish from a projection graph.

• The darker the shade of blue, the greater the attenuation coefficient of the material.

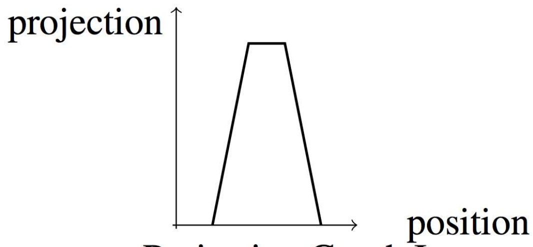
• For all objects except 2f, the width of each object at its widest point is equal to the width of the graph at its widest point.

Objects for Both Projection Graphs



View Larger Image
View Description

Projection Graph 1



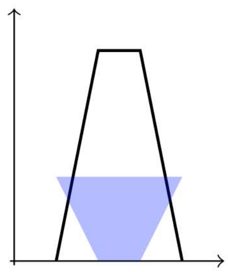
Projection Graph I

- [ ] a. Object a
- [ ] b. Object b
- [ ] c. Object c
- [ ] d. Object d
- [ ] e. Object e
- [x] f. Object f ✔
- [x] g. Object g ✔
- [x] h. Object h ✔
- [ ] i. Object i
- [ ] j. Object j

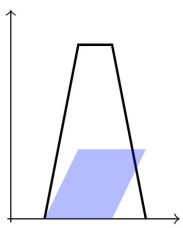
✔

Explanation

For Projection Graph I, 2g, 2h, and 2f are valid. In the graph, the attenuation increases linearly from zero, then remains constant and then decreases linearly in a symmetric way. If the object has constant attenuation, this means the object's thickness needs to increase from a point (zero attenuation) linearly, then follow this with a portion of uniform thickness, then have decreasing thickness symmetric across a vertical line through the middle. This does not mean the object must itself be symmetric, only its thickness.

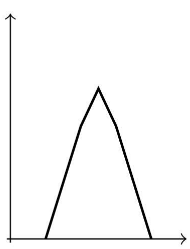


Projection Graph I



Projection Graph I

Projection Graph 2



Projection Graph II

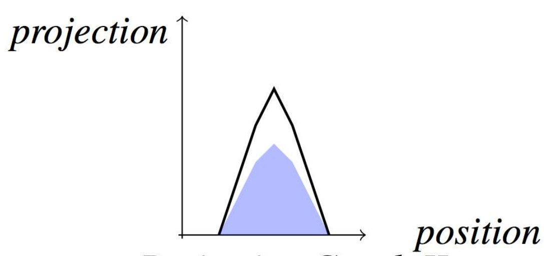
- [ ] a. Object a
- [ ] b. Object b
- [x] c. Object c ✔
- [ ] d. Object d

- [x] e. Object e ✔
- [ ] f. Object f
- [ ] g. Object g
- [ ] h. Object h
- [ ] i. Object i
- [ ] j. Object j

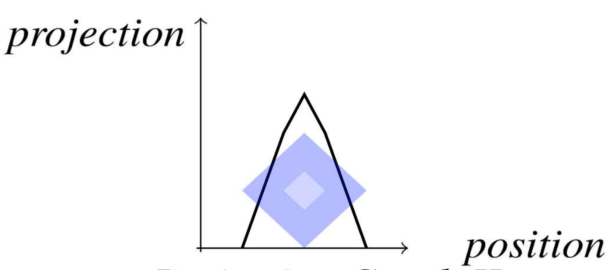
✔

Explanation

For Projection Graph II, 2c and 2e are valid. The key is that the object must increase in attenuation in the middle section but at a lesser rate than on the left and right. This can happen either by becoming thick at a lesser rate or having a portion of the object in the middle with lower attenuation (a lighter shade of blue.)



Projection Graph II



Projection Graph II

Submit You have used 5 of 6 attempts

Answers are displayed within the problem

Question 3

1/1 point (graded)

Imagine a single x-ray traveling through a 1-dimensional object. If the input intensity is 80 kVp and the output intensity is 4 kVp, what is the value of the projection? Round your answer to the nearest hundredth.

(Source for numbers: https://en.wikipedia.org/wiki/X-ray "The voltages used in diagnostic X-ray tubes range from roughly 20 kV to 150 kV and thus the highest energies of the X-ray photons range from roughly 20 keV to 150 keV.[18]".)

3

Answer: 3

3

Explanation

$-ln(4/80) = -ln(.05) \approx 3.00$ This would be representative of traveling through about 3 cm of muscle.

Submit

You have used 1 of 3 attempts

Answers are displayed within the problem

Question 4

1/1 point (graded)

Suppose when sending a single x-ray through an object with uniform attenuation and which is 4 cm thick, you get a projection value of 2.

Recall the attenuation coefficients of these materials:

Material	μ **(cm^{-1})**
Blood	0.2
Bone (cortical)	6.9

Material	**(cm)**
Bone (trabecular)	9.64
Brain	0.6
Cardiac	0.52
Enamel	120
Fat	0.48
Muscle	1.09
Soft Tissue (average)	0.54
Water	0.0022

Which is the object possibly made of? Choose all that are possible.

- [ ] water
- [x] soft tissue ✔
- [ ] bone
- [x] fat ✔
- [ ] muscle
- [ ] none of the above.

✔

Explanation

Answer: fat

We know $I = I_0 e^{-\mu L}$, and so $p = -\ln(I/I_0) = \mu L$. Thus if $p = 2$ and $L = 4$ cm, then $\mu = 0.5$ cm^{-1} which corresponds to either cardiac tissue, fat or soft tissue.

Numerical Input

Remember the attenuation coefficient of soft tissue is 0.54 cm^{-1} and bone (cortical) is 6.9 cm^{-1}. How thick would the soft tissue need to be to be mistaken for a 1 cm of bone on an x-ray? Round to the nearest tenth

Answer: 12.8 cm (round to nearest tenth).

We know $I = I_0 e^{-\mu L}$, and so $p = -\ln(I/I_0) = \mu L$. Thus the projection value through 1 cm of bone would be 6.9. If $p = 6.9$, and $\mu = 0.54$ cm^{-1}, then $L = \frac{p}{\mu} \approx 12.8$ cm.

Submit You have used 1 of 3 attempts

Answers are displayed within the problem

Question 5

1/1 point (graded)

Remember the attenuation coefficient of soft tissue is 0.54 cm^{-1} and bone (cortical) is 6.9 cm^{-1}. How thick would the soft tissue need to be to be mistaken for a 1 cm of bone on an x-ray? Round to the nearest tenth.

12.8 ✔ **Answer:** 12.8

12.8

Explanation

Answer: 12.8 cm (round to nearest tenth).

We know $I = I_0 e^{-\mu L}$, and so $p = -\ln(I/I_0) = \mu L$. Thus the projection value through 1 cm of bone would be 6.9. If $p = 6.9$, and $\mu = 0.54$ cm^{-1}, then $L = \frac{p}{\mu} \approx 12.8$ cm.

Submit You have used 1 of 3 attempts

Answers are displayed within the problem

Question 6

1/1 point (graded)

Suppose we are considering a single x-ray of initial intensity I_0 passing through a non-uniform object with attenuation function $\mu(x)$ and thickness L. Let I be the output intensity.

Assuming you have a calculator handy which can compute logarithms, which of the following could you easily determine from knowing the initial intensity of the ray I_0 and the resulting intensity I? Choose all that apply.

- [x] I/I_0, the ratio of the resulting intensity to the initial intensity ✔
- [x] p, the projection number, $= -\ln(I/I_0) = \int_0^L \mu(x)\,dx$ ✔
- [ ] $\mu(x)$, the function giving the attenuation at each point along the line through the object
- [x] $\int_0^L \mu(x)\,dx$, the integral of $\mu(x)$ ✔

✔

Explanation

A: Everything but choice C. Choice A is the ratio of I_0 and I, Choice B is the negative natural logarithm of this ratio, and Choice D is equal to B. All of these would be able to be computed with a standard scientific calculator. The function $\mu(x)$ however is not something we can find just knowing I_0 and I. It is more work to find $\mu(x)$ and requires multiple x-rays.

Submit You have used 1 of 2 attempts

Answers are displayed within the problem

Question 7

1/1 point (graded)

Imagine a single x-ray of initial intensity I_0 traveling through a non-uniform object of length L and with varying attenuation coefficient $\mu(x)$.

Margo explained the process as follows:

- Slice the object into n equal slices of width Δx.
- Sample the attenuation in slice to get μ_1 for the first slice, μ_2 for the second slice and so on.

- Use the Lambert-Beer Model, and compute $I_1 \approx I_0 e^{-\mu_1 \Delta x}$, $I_2 \approx I_1 e^{-\mu_2 \Delta x}$, $I_3 \approx I_2 e^{-\mu_3 \Delta x}$ and so forth.

The resulting intensity of this x-ray after passing through all n slices, is approximately $I_0 e^{-\sum_{i=1}^{n} \mu_i \Delta x}$. Why is this only an approximation of the resulting intensity? Choose the most reasonable answer.

- ○ This is only an approximation since I_0 is an approximation of the initial intensity
- ○ We computed $I_2 \approx I_1 e^{-\mu_2 \Delta x}$ and so on, but we should actually compute $I_2 \approx I_0 e^{-\mu_2 \Delta x}$ since the initial intensity is the same for each slice. .That is why this is only an approximation.
- ◉ This is only an approximation since when we compute $I_1 \approx I_0 e^{-\mu_1 \Delta x}$ and so on, we treat the attenuation in each slice as a constant, but it might not actually be constant. ✔
- ○ It's a sum of numbers so it must be only an approximation.

Submit

You have used 1 of 2 attempts

Answers are displayed within the problem

Learn About Verified Certificates

English ▼