NTSC 395
SECOND HOUR EXAM--
SOLUTIONS

1. Your graph needed to show that the noon sun was highest in June and lowest in December; this is due to the obliquity (tilt of the Earth) and is the factor responsible for seasons on the Earth. Additionally, your graphs needed to show that the sun rises latest and sets earliest in December and rises earliest and sets latest in June. Several of you said that the altitude of the noon sun in June vs. December is the result of the Earth Sun distance. This is incorrect. The sun is actually closest to the Earth in early January and the Earth Sun distance variation has nothing to do with seasons on the Earth.

2. For both parts of the problem, we use the thin lens equation :

$$\frac{1}{\text{obj. distance}} + \frac{1}{\text{image distance}} = \frac{1}{\text{focal length}}$$

a) Here, the object distance is 20 cm and the focal length is 10 cm :

$$\frac{1}{20\text{ cm}} + \frac{1}{i} = \frac{1}{10\text{ cm}} \Rightarrow \frac{1}{i} = \frac{1}{10} - \frac{1}{20} = \frac{2}{20} - \frac{1}{20} = \frac{1}{20}$$

$$\frac{1}{i} = 20 \Rightarrow i = 20\text{ cm};$$

The image distance is + 20 cm; this means the image forms behind the lens (on the side opposite the object.)

b) $$\frac{1}{o} + \frac{1}{i} = \frac{1}{f}$$

$$\frac{1}{5} + \frac{1}{i} = \frac{1}{10} \Rightarrow \frac{1}{i} = \frac{1}{10} - \frac{1}{5} = \frac{1}{10} - \frac{2}{10} = \frac{-1}{10}$$

$$\frac{1}{i} = \frac{-1}{10} \Rightarrow i = -10\text{ cm}$$

The image distance is - 10 cm; the image forms 10 cm from the lens, on the same side of the lens as the object.

3. These are graphs of distance vs. time. Many students interpreted them to be graphs of speed vs. time. In graph a), the object moves at a certain speed until t = 3, increases its speed until t = 4, and is stationary from t = 4 to t = 5.

In graph b), the object moves forward until t = 3, at which point it reverses its direction of motion (between t = 3 and t = 4, travels at the same speed as it did from t = 0 to t = 3); at t = 4 the speed toward the origin increases.

Graph c) is impossible; either the object is traveling backward in time or can be in two places at once.

4. a) We can do a) in one of two ways (which will give slightly different answers). We can compute the value of the stock fund at the beginning of each year. If the fund increases value by 10 %/year, we can write :

Value at t = 0 = \$1000
Value at t = 1 = \$1000 + 0.1 x\$1000 = \$1100
Value at t = 2 = \$1100 + 0.1 x\$1100 = \$1210
Value at t = 3 = \$1210 + 0.1 x1210 = \$1331
Value at t = 4 = \$1331 + 0.1 x1331 = 1464.10
Value at t = 5 = \$1464 .10 + 0.1 x1464 .10 = 1610.51

We could also compute the value at t = 5 by assuming continuous rather than discrete growth; this would involve the use of the equation :

$$\text{value}(t) = \text{value}(0)\, e^{0.1/\text{yr} \times 5\ \text{yrs}} = 1000\, e^{0.5} = 1648.72$$

In the first calculation, we assumed discrete growth, compounding the money only at the end of every year. In the second case, we assume continual growth. You can see that the continual growth assumption yields a larger value.

b) If the half - life is ten days, then each ten days the mass of original substance is halved. If we started with 128 grams, we will have half of that, or 64 grams after ten days; 32 grams after 20 days; 16 grams after 30 days; 8 grams after 40 days, and 4 grams remaining after 50 days.

5. While almost all students were able to articulate two (or more) important points contained in RAGS, a fewer number were able to cite any evidence or data from RAGS in support of these positions. As an example of evidence, if you discussed the need for more and better trained science educators, you could point to the statistics that show on order of 70 % of K - 12 teachers in science hold no qualifications/degrees/endorsement/certifications to teach science. If you talked about the need for more research, you could have cited the data showing how the rest of the world is producing a larger fraction of the patents and publishable papers compared to the past, and that this suggests a time in the future when other countries might surpass the rate at which the US produces new knowledge.

6. The class did very well in describing taking an object, forming an image with the lens, measuring both object and image distance, and using the equation used above in question 2 to find the focal length.