Physics 131 – Test 2 – Fall 2007

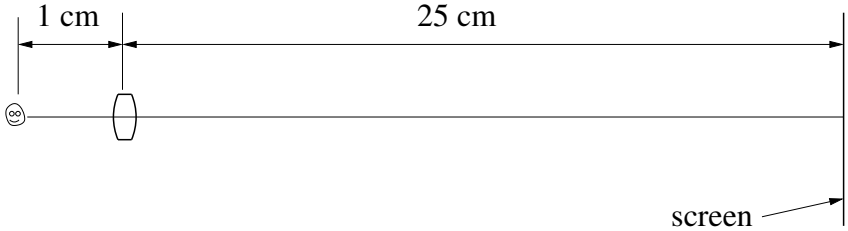
One-page reminder sheet allowed. *Show all work – no credit given if work not shown!*

1. An amoeba 0.01cm in diameter has its image projected on a screen as shown below by a positive lens of diameter 0.1cm as shown below.

   (a) How big is the image of the amoeba?

   (b) What is the focal length of the lens?

   (c) What is the minimum distance between features on the image of the amoeba which can be resolved? Assume that the wavelength of light used is 5×10^{-7}m. (Hint: What is the spreading angle of a beam of light passing through an opening the size of the lens?)



2. An interstellar spaceship pilot going from Earth to Sirius (8ly distant) ages by 2y during this trip.

   (a) Draw a spacetime diagram illustrating her journey. Include and label the world line and a line of simultaneity of the moving spaceship.

   (b) How much does her Earth-bound brother age during this journey? (Calculate in the reference frame of the Earth.)

   (c) How fast (as a fraction of the speed of light) is the spaceship traveling during the trip?

   (d) In the reference frame of the moving spaceship, what is the separation of Earth and Sirius?

3. The wave four-vector for a relativistic wave is $\underline{k} = (k, \omega/c) = (30, 50)\text{m}^{-1}$.

   (a) Draw a spacetime diagram showing this wave four-vector. Draw the wavefronts of the wave, indicating their slopes.

   (b) Compute the phase speed of the wave as a fraction of the speed of light.

   (c) What is the value of ω/c in a reference frame in which the space component of $\underline{k}$ is zero?

4. A man is in an elevator accelerating upward at $a = 1.2g$ (in the reference frame of the Earth) where g is the Earth's gravity.

   (a) If the man has a mass of M, derive an expression for the magnitude and direction of the inertial force on the man in the reference frame of the elevator, ignoring Einstein's general theory of relativity.

   (b) Repeat this calculation taking general relativity into account.

   (c) Derive an expression for the direction and magnitude of the acceleration of the elevator in the reference frame of the Earth if the inertial force on the man (taking general relativity into account) suddenly goes to zero.

5. Non-relativistic Doppler shift: A stationary source of sound waves with phase speed c (not the speed of light!) is observed by an observer moving to the right at speed v, as shown below. Note: Galilean, not Einsteinean relativity applies here.

   (a) Identify the period of the sound wave (i) in the reference frame of the source, and (ii) as perceived by the observer in the diagram below.

   (b) Compute the period as measured by the observer as a function of c and v and the wave period in the reference frame of the source.