CPSC 4278

FIRST PUBLIC EXAMINATION

TRINITY TERM

Preliminary Examination in Physics

Paper CP4: DIFFERENTIAL EQUATIONS, WAVES AND OPTICS

Thursday, 8 June 2006, 2.30 pm – 5.00 pm

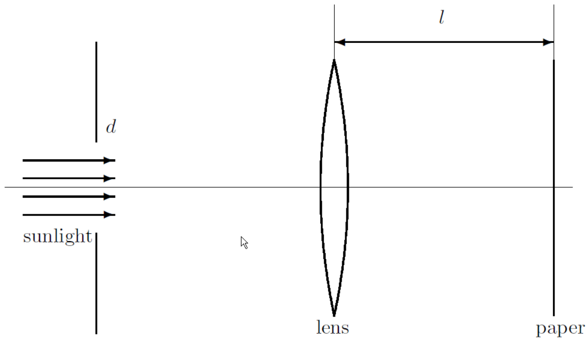
Time allowed: $2\frac{1}{2}$ hours

6. A point like object moves away from a concave mirror with focal length f along the principal axis at constant velocity v_o. It starts at the mirror surface at time $t = 0$. Calculate and briefly discuss how the velocity and position of its image change as a function of time. [6]

7. An optical system produces an inverted image of an object O. A thin lens of focal length f is to be used to transform this image into an upright one and magnify it by a factor of 2. Which type of lens is needed? Draw an optical setup which can be used to achieve this. Find the distances between the inverted image, the upright magnified image and the lens. Check your answer geometrically with the help of your drawing. [5]

8. A normally illuminated diffraction grating with $N = 500$ lines per mm produces multiple diffraction maxima the first being at an angle of $\theta = 10°$. Find the angular frequency ω of the light used to illuminate the grating. [4]

9. Light passing through a convex lens of focal length $f = 20\text{cm}$ is used to illuminate a sheet of paper distance l away from the lens. The incoming light beam has diameter $d = 1\text{cm}$ and is arriving from the sun.



Explain why the light from the sun may be assumed to be collimated. The light intensity coming from the sun is $S = 1{\cdot}37\text{kW/m}^2$. Calculate the light intensity I arriving at the sheet of paper and the illuminated area A as a function of the distance l. [5]

The temperature T of the illuminated area A changes with time t according to

$$c\frac{\mathrm{d}T}{\mathrm{d}t} = I - \alpha(T - T_0)\,,$$

where $T_0 = 293\text{K}$ is the ambient temperature and $c = 170\text{J/Km}^2$, $\alpha = 250\text{W/Km}^2$ are constants. Assuming that the ignition point of the paper is $T_i = 506\text{K}$ find the range of distances l for which the paper will start to burn. How long will the light need to heat up the paper to T_i? [9]

Explain what happens when $l = f$. Give a realistic estimate of the maximally achievable intensity I for a mean wavelength of $\lambda = 500$nm taking into account the resolution of the lens. What is the shortest possible time needed to heat the paper to T_i? [6]