P1. Convex spherical mirror (20%)  
Given: $R = 20 \text{ mm}$, $h_0 = 8 \text{ mm}$, and $p = 30 \text{ mm}$.  
Find:  
   a) Focal length, $f$. Ans.  
   b) $q$. Ans.  
   c) $h_i$. Ans.  
   d) Ray-diagram confirmation on diagram.  
   e) Is the image real or virtual? Ans.  

P2. Concave spherical mirror (20%)  
Given: $R = 20 \text{ mm}$, $h_0 = 8 \text{ mm}$, and $p = 40 \text{ mm}$.  
Find:  
   a) Focal length, $f$. Ans.  
   b) $q$. Ans.  
   c) $h_i$. Ans.  
   d) Ray-diagram confirmation on diagram.  
   e) Is the image real or virtual? Ans.  

P3. Convergent/divergent thin-lens (30%)  
Given: $f_1 = 10 \text{ mm}$, $h_{01} = 8 \text{ mm}$, and $p_1 = 20 \text{ mm}$.  
Find:  
   a) The image location, $q_1$. Ans.  
   b) The image height, $h_{i1}$. Ans.  
   c) Ray-diagram confirmation for the 1st lens  
   d) Is the image real or virtual? Ans.  
   e) If the 2nd divergent lens (dashed) with $f = -30 \text{ mm}$ is placed in the observer side, and separated with the 1st lens by 10 mm, find the final image location respect to the 2nd lens, (6%) Ans.  
   and the final image height, $h_{i2}$, (2%) Ans. and indicate it on left.  

P4. Wave diffraction/interference (30%)  
A single-slit diffraction/interference pattern (Fig. 1) was taken using a $5 \text{ mW}$ ($\text{mW} = 10^{-3} \text{ W}$) HeNe laser ($\lambda = 632.8 \text{ nm}$, $1 \text{ nm} = 10^{-9} \text{ m}$) under the condition: the distance between the slit and screen is 3 m.  
   a) (5%) Assume circular laser beam cross-section with a diameter of 0.003 m, find the laser energy flux, Ans.  
   b) (5%) Find the electric field intensity at the slit, Ans.  
   c) (5%) Indicate the dark locations of $m = \pm 1$, $\pm 2$, $\pm 3$ on the figure below:  
   d) (15%) Find the slit width in unit of $\mu m$ ($1 \mu m = 10^{-6} \text{ m}$), Ans.  

Fig. 1  

Reference Equations:  
Mirror (or thin-lens) equation: $q = pf/(p - f)$, $M = -q/p$, $h_i = M h_0$, for mirror case, $f = \pm R/2$  
Diffraction/Interference: Two-slit bright condition: $\sin(\theta_0) = m \lambda$, $m = 0, \pm 1, \pm 2, \pm 3$…Single-slit dark condition: $\sin(\theta_0) = m \lambda$, $m = \pm 1, \pm 2, \pm 3$…Small-angle approximation: $\sin(\theta) \sim \tan(\theta) \sim y/L$. $S_{EM} = c_0 E^2$, $c = 3 \times 10^8 \text{ m/s}$, $c_0 = 8.85 \times 10^{-12} \text{ F/m}$