

**Instructions: You have a total of 50 minutes to complete this test.
Answer each of the following questions completely.**

Time Start _____ Time finish _____ Pledged _____

[1] (a) When a beam of light travels through a material with an index of refraction of 4.0 and strikes an interface with air, at what angle of incidence will the light be completely reflected internally?

(b) A material has an index of refraction of 4.0 and is surrounded by air. When light is incident (from the air) on this material at an angle of 30° , what is the angle of refraction?

(c) At what angle will a beam of light striking this material (from the air) produce a reflected beam that makes an angle of 90° with respect to the refracted beam?

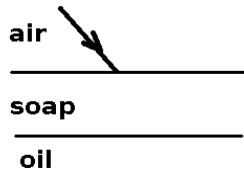
(d) A diffraction grating with $N=50000/\text{m}$ is illuminated by light of 700 nm. What is the maximum order of dots observed in the diffraction pattern?

(e) A TEM wave has an electric field amplitude of 1×10^4 V/m. What is the time average energy density of the TEM wave if $\epsilon_0 = 8.86 \times 10^{-12} \text{ J m}^2/\text{V}^2$?

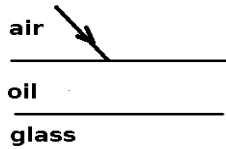
[2] (a) Suppose lens L1 has a focal length of +30 cm. This lens is in direct contact with a second lens named L2. If an object is placed 5 cm from the lens combination, the resulting magnification is seen to be $M=2$. Find the focal length of the second lens in the combination.

(b) Characterize the image that is formed when an object is placed 10 cm in front of the lens combination in terms of [<no image forms> | <Real:Virtual> <Upright:Inverted> <Enlarged:Unmagnified:Reduced>] and tell why.

(c) What is the smallest diameter of lens (in m) that can just resolve two images at a distance of 1000 m separated by a distance of 1.0 m if the sources emit light with a wavelength of 500 nm?



[3] (a) A soap film has an index of refraction of 2.0 and is of thickness t . The film is on an oil film with an index of refraction of 4.0, and air is on the other side of the soap. What is the minimum thickness of the soap film that will show an absence of reflected light at a wavelength of 400 nm?



(b) Suppose an oil film had an index of refraction of 4.0 and was on a slide with an index of refraction of 8.0 with air on the other side of the oil. What is the minimum thickness of the oil film that would strongly reflect light of 400 nm which is normally incident from the air?

(4) When an object is placed at a distance of 8 cm from a lens, the magnification is -5.

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

(b) If the object is placed at 10 cm from the same lens, what is the magnification of the image?

(c) Characterize the image formed in (b) by [<no image forms> | <Real:Virtual> <Upright:Inverted> <Enlarged:Unmagnified:Reduced>] and tell why.

(5) (a) When an object is placed 10 cm from a mirror, an image is formed at -20 cm. What is the radius of curvature of the mirror?

(b) What is the magnification when an object is placed 2 cm from the same mirror?

(c) Characterize the image formed in (b) by [<no image forms> | <Real:Virtual> <Upright:Inverted> <Enlarged:Unmagnified:Reduced>] and tell why.