# PHYS 3220 - Spring 2019 – Exam 3
(due Tuesday April 23, 2019)

This is a take-home exam. You may consult your books or other reference material. You may not consult any other person about how to solve the problems in this exam. Your score based on the correctness of the solution and on the logic and clarity of your writing. Cite all sources you use. Sign the statement below and return it with your completed exam by the end of class Tuesday April 23, 2019.

1. (10 points) Purcell and Morin Exercise 9.26 (An electromagnetic wave).

2. (10 points) Fowles 2.17 (Brewster angle).

3. (10 points) (The angle of the rainbow) The figure on the right shows René Descartes' sketch of how a rainbow is formed (*Discours de la méthode*, 1637). a light ray from the Sun (AB) enters a raindrop at B and undergoes two refractions (at B and D) and a total internal reflection (at C). The purpose of this problem is to show that the angle DEM at which an observer sees the rainbow is approximately $42°$. Assume the raindrop is spherical and show that the angle α between the lines AB and DE, which is equal to the angle DEM, is given by $\alpha(\theta) = 4\sin^{-1}(\sin(\theta)/n) - 2\theta$, where θ is the angle of incidence and $n = 1.33$ is the index of refraction of the raindrop. More outgoing rays concentrate near the maximum of the function $\alpha(\theta)$. This maximum angle $\alpha_{\max}$ is the angle at which the rainbow appears.
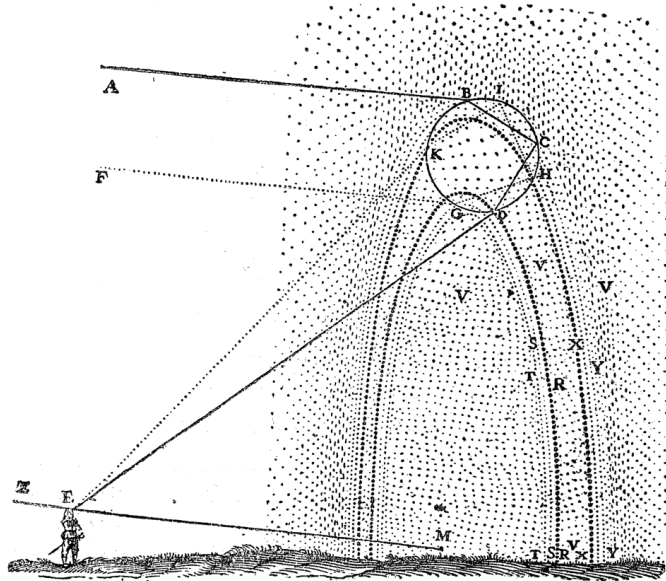
4. (10 points) A narrow slit (in air) in an opaque screen is illuminated by red light from a He-Ne laser at 632.991 nm (vacuum wavelength). It is found that the zero-intensity point of the tenth dark band in the Fraunhofer pattern lies at an angle of $3.628°$ off the central axis. Determine the width of the slit. At what angle will the tenth minimum appear if the slit-detector arrangement is immersed in water at $20°$ C ($n = 1.3321$) instead of air ($n = 1.00029$)?

I affirm that I have had no conversation regarding how to solve the problems in this exam with any person, and I certify that the attached work represents my own thinking.

Signature: _____