Time of completion _____ Cadet _____ Section_____
7 October 2003 Version 2

DEPARTMENT OF PHYSICS
PH203, Physics I
Written Partial Review I

1. Instructions:

   a. Bring only your hand-held calculator, a straight-edge, and pencil(s) into the examination room.

   b. Check your exam for five problems and two bonus problems on seven pages. Write your name and section at the top of each page. Check for the Physics Reference Card provided with the exam.

   c. For calculation problems, **show all work**; partial credit will be given for correct work shown.

   d. Take up to 55 minutes to complete the examination. If you leave early, record your time of completion above.

   e. BONUS problems are optional.

2. An instructor is in the hall.

3. Grading summary (**for instructor use only**):

PROBLEM	WEIGHT	SCORE
1	90	
2	90	
3	50	
4	70	
5	50	
SUBTOTAL	350	
BONUS	20	
TOTAL	350	

_____%

Wt. No. Cadet_____

90 1. The seismic array at Burnt Mountain, Alaska, is used by the military in its mission to monitor and verify international nuclear treaty compliance. The power used at this site is provided by 10 radioisotope thermoelectric generators (RTGs) containing capsules of strontium titanate. In order to meet the power requirement of nine watts each capsule must still contain 9.68 g of ^{90}Sr at the end of its programmed life. The half-life of ^{90}Sr is 28.8 years, and its atomic mass is 89.90774 u.

(60) a. The RTGs were designed to be used for 46.3 years before being replaced. Calculate the initial mass of ^{90}Sr required in each RTG to meet the end-of-life power requirement.

$m_o = \underline{\underline{0.0295 \text{ kg}}}_{\text{ANS}}$

(30) b. Calculate the number of atoms of ^{90}Sr remaining in each RTG at the end of its useful life.

$N = \underline{\underline{6.48x10^{22} \text{ atoms}}}_{\text{ANS}}$

Wt. No. Cadet_____

90 2. Onboard a C-141 cargo aircraft headed for Ramstein Air Base, Germany, the pilot forcefully pushes down on the left rudder peddle, initiating a sudden left turn. As a result, a transverse wave propagates along the taut cable connecting the rudder pedal to the hydraulic rudder control assembly. The cable's linear mass density is 0.962 kg/m. The equation for the traveling wave is:

$$y(x,t) = (0.0100\text{ m})\sin[(2.15\pi\text{ rad/m})x - (89.5\pi\text{ rad/s})t]$$

(30) a. Calculate the wavelength for this wave.

$\lambda = \underline{\underline{0.930\text{ m}}}_{\text{ANS}}$

(30) b. Calculate the speed of the transverse wave.

$v = \underline{\underline{41.6\text{ m/s}}}_{\text{ANS}}$

(30) c. Assume the answer to part b. is 40.5 m/s. Calculate the magnitude of the tension in the taut cable.

$\tau = \underline{\underline{1{,}580\text{ N}}}_{\text{ANS}}$

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50 3. While conducting an underwater recovery of the passengers aboard a crashed CH-53E helicopter, you and your partner find yourselves trapped within the water-filled cockpit of the helicopter. Hoping to signal a third team member swimming outside the helicopter, you shine your flashlight toward the team member at an angle to the helicopter's glass windshield (index of refraction of 1.22). The flashlight beam is incident on the glass windshield at an angle of 75.0^{o} and does not refract through the glass.

(20) a. State the physical principle represented in this situation, and describe the condition under which this can occur in a medium.

Total internal reflection ANS

The index of refraction of the medium **in** which the incident light is propagating, n_1, must be greater than the index of refraction of the medium **on** which the light is incident, n_2, i.e., $n_1 > n_2$. ANS

(or)

The angle of incidence is greater than the critical angle. ANS

(20) b. Assume the index of refraction of water is 1.33. You move the flashlight to a new position in the cockpit. Calculate the angle of incidence at which your third team member will first see the flashlight beam.

$\theta_c = 66.5^{o}$ ANS

3. (cont'd)

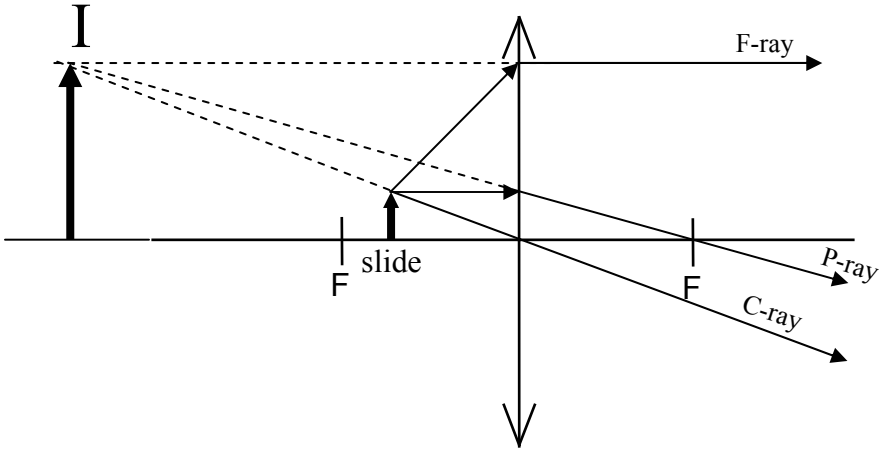
(10) c. Assume instead that the light is incident on the glass at Brewster's angle. Upon removing his diving mask your partner realizes that the reflected light is less intense with the diving mask on. Given that the mask is coated with a polarizing film and the intensity of the reflected light that passes through the mask is 75.5% of the total reflected intensity, calculate the angle between the polarizing direction of the diving mask and the direction of polarization of the reflected light.

$\theta = \underline{\underline{29.7^o}}_{\text{ANS}}$

Wt. No. Cadet_____

70 4. As an Army Research Laboratory technician working in the Bioengineering Division, you prepare to analyze a specimen of anthrax by placing it on a microscope slide. You place the slide 1.63 cm in front of a converging lens with a focal length of 2.44 cm.

(20) a. Construct a three-ray diagram to locate the image. Draw and label the image on your three-ray diagram.



(25) b. Calculate the image distance.

$i = \underline{\underline{-4.91\,\text{cm}}}_{\text{ANS}}$

(25) c. Calculate the magnification of the image.

$m = \underline{\underline{3.01}}_{\text{ANS}}$

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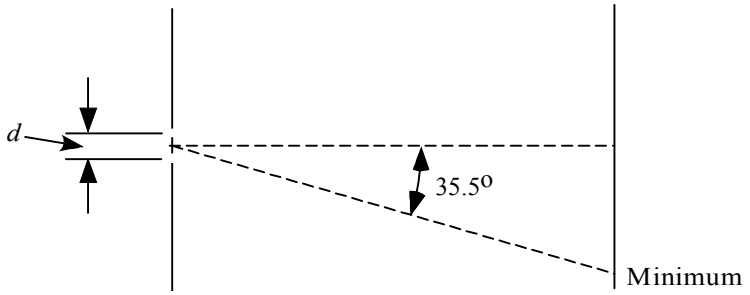
50 5. While working as a scientist in the Army Research Laboratory, you demonstrate Young's double-slit experiment to a group of visiting USMA Cadets. In the performance of the experiment a dark interference fringe (or minimum) is observed at the angle shown. The slits are 3.57 μm apart, and the light source used is an Argon laser with an operating wavelength of 461 nm.



(40) a. Calculate which dark spot is observed, i.e., the 1st, 2nd, 3rd, etc. dark spot.

The 5th Dark Spot
ANS

(10) b. Young's double-slit experiment demonstrated that light (circle the single, most correct answer)

1. is monochromatic.
2. is made up of photons.
3. contains all the colors of the rainbow.
4. is a wave.

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10 BONUS For problem 2, calculate the transverse speed of the medium at a distance of 10.1 cm from the rudder pedals after 2.96 s has elapsed.

$u = \underline{\underline{1.67 \text{ m/s}}}_{\text{ANS}}$

10 BONUS List and describe the five characteristics of a nuclear explosion.

1. The fireball—an extremely hot and highly luminous spherical mass of air formed by the absorption of x rays by the atmosphere.
2. The radioactive cloud—a cloud containing solid particles of the weapons debris, as well as many small drops of water derived from the air sucked into the rising fireball.
3. The fallout—radioactive particles and vapor products that gradually descend to the earth.
4. The blast wave—a high-pressure wave that moves outward from the fireball.
5. The electromagnetic pulse—an electric field created by the separation of charge that travels outward from the nuclear blast.

ANS