

QUESTION 10

You are the designated laser safety officer (LSO) of a major research facility that operates a continuous wave (CW) neon gas laser. The laser is operated from the center of a laboratory that is 20-meters square. The beam is directed towards the center of one wall where it terminates on a diffusely reflecting target that is mounted to the wall. The target reflectivity factor, ρ_λ , is 0.90. The laser has the following operating parameters:

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Power:	20 W
Beam diameter (1/e):	2 mm
Beam divergence:	1 mrad
Wavelength:	540 nm

**Maximum Permissible Exposure for Direct Ocular
Exposure Intra-beam Viewing from a Laser Beam***

Wavelength λ (μm)	Exposure Time t(s)	MPE
0.400 to 0.700	10^{-9} to 1.8×10^{-5}	$5 \times 10^{-7} \text{ J cm}^{-2}$
0.400 to 0.700	1.8×10^{-5} to 10	$1.8t^{3/4} \times 10^{-3} \text{ J cm}^{-2}$
0.400 to 0.550	10 to 10^4	$1 \times 10^{-2} \text{ J cm}^{-2}$
0.550 to 0.700	10 to T_1	$1.8t^{3/4} \times 10^{-3} \text{ J cm}^{-2}$
0.550 to 0.700	T_1 to 10^4	$10C_B \times 10^{-3} \text{ J cm}^{-2}$
0.400 to 0.600	10^4 to 3×10^4	$C_B \times 10^{-6} \text{ W cm}^{-2}$

* $C_B=1$ for $\lambda = 0.400$ to $0.550 \mu\text{m}$; $C_B = 10^{(15[\lambda-0.550])}$ for $\lambda = 0.550$ to $0.700 \mu\text{m}$;

$T_1 = 10 \times 10^{[20(\lambda-0.550)]}$ second for $\lambda = 0.550$ to $0.700 \mu\text{m}$. [From ANSI Z136.1 (1986)].

POINTS

20 A Match the following radiometric quantities to their appropriate units.

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|----------------------|---------------------------------------|
| 1. Radiant energy | a. W cm^{-2} |
| 2. Radiant power | b. W sr^{-1} |
| 3. Radiant intensity | c. J |
| 4. Radiance | d. $\text{W sr}^{-1} \text{ cm}^{-2}$ |
| 5. Radiant exposure | e. J cm^{-2} |
| | f. W |
| | g. $\text{J sr}^{-1} \text{ cm}^{-2}$ |

- 12 B Briefly define and describe each of following terms. Why is the specification of a NHZ more appropriate for indoor laser laboratories?
1. Nominal Hazard Zone (NHZ)
 2. Nominal Ocular Hazard Distance (NOHD)
- 30 C Estimate and describe the nominal hazard zone (NHZ) for this laser laboratory? Assume the intrabeam MPE applies. **Show all work.**
- 20 D What is the minimum optical density (OD) of protective eyewear required to reduce the laser irradiance below the intrabeam MPE. Assume a 0.25-second accidental viewing time. **Show all work.**
- 10 E Assume a minimum OD of 5 is required for the protective eyewear. A researcher has obtained specifications from three proposed laser eyewear manufacturers. These eyewear have the following optical densities (OD) at the indicated wavelengths and luminous transmission values:

Specifications	Brand X	Brand Y	Brand Z
OD @ 400nm	3	5	5
OD @ 450 nm	4	7	7
OD @ 500 nm	5	7	8
OD @ 540 nm	5	7	8
OD @ 600 nm	3	4	7
OD @ 650 nm	1.5	3	6
Luminous Transmission	35 %	6 %	<1 %

Which manufacturer’s eyewear (Brand X, Y, or Z) would you recommend as best to use in this laser laboratory and why? **Justify your answer.**

- 8 F Match the following FDA laser class with the appropriate characteristic that BEST describes the class.
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|--------------|---|
| 1. Class I | a. can damage skin or eye from diffuse reflection |
| 2. Class II | b. not an ocular hazard |
| 3. Class III | c. 0.25 second exposure threshold |
| 4. Class IV | d. momentary intrabeam viewing is hazardous |