Ref. No. : Ex/PG/LST/T/123A/2018

M.TECH. LASER SCIENCE & TECHNOLOGY FIRST YEAR SECOND SEMESTER – 2018

LASER AUTOMATION, IN PROCESS SENSING AND LASER SAFETY

Time: 3 hr Full Marks: 100

Answer any *five* questions.
Assume suitable data if necessary.

1. a) How is the order of the system determined?

   b) A second order system is subjected to a step input. Find out the response and also show the transient response of the second order system to unit step function for different values of damping factor.

   c) A second order system follows the differential equation given as

   $$d^2I_0/dt^2 + 3\ dI_0/dt + 30\ I_0 = 30\ I_i$$

   where I_0 = output signal

   I_i = input signal.

   Determine the damping ratio, the damped natural frequency, the static sensitivity and the time constant. **3 + 7 + 10**

2. a) When a step input was given to a second order system, it was revealed that the system had an overshoot of 12% in a rise time of 0.22 s. Determine the effective damping ratio and the undamped natural frequency of the system.

   b) A unit amplitude sinusoidal input signal having a frequency of 0.6 Hz is given to a second order system of transfer function $I_0/I_i = 8/(D^2+4D+20)$. Develop an expression for the steady state response of the system and determine the corresponding output amplitude, output frequency and phase lag.

   c) Show the variation of amplitude ratio and phase lag with frequency ratio with harmonic input to a second order system. **7 + 8 + 5**

3. a) What is beam reflection? Derive the expression for integrated radiance in energy terms.

   b) For laser beams of circular cross section, explain the three measurement situations in connection with power through aperture.

c) An Nd: YAG laser with power of 40 W is projected on to fully dilated human eye pupil of 7 mm diameter. The eye is exposed for duration of 10 s. Calculate the minimum optical density of a laser safety goggle needed to protect the eye from damage. The MPE for the case is 0.0051 W/cm^2. **8 + 5 + 7**

4. a) In assessing risk during use of laser, discuss the two primary factors involved. Also give a graphical representation of the process of risk assessment.

b) Show that NOHD= $[4P/\pi. MPE]^{0.5}/\theta_{63}$ where the notations carry usual meanings.

c) A CO_2 laser with a power P of 500 W and exit beam diameter b out of the laser of 3 cm is focused by a convex lens of focal length f_o=20 cm. Determine the NHZ from the focal point of the lens. The MPE is 0.1 W/cm^2. The NHZ is given by the expression $f_0(4P/\pi.MPE)/b$. **6 + 8 + 6**

5. a) Discuss about the safety rules for all lasers, regardless of output power level.

b) If I= radiant density, E = irradiance produced, then establish a relationship between I and E at a distance x from the source.

c) Explain the terms: peak irradiance and FWHM. **7 + 8 + 5**

6. a) What are the different classes of laser? Explain them with suitable examples..

b) Briefly discuss about the absorption of radiation by the eye.

c) A 1 mW laser beam with divergence of 0.5 mrad enters the eye. Find the irradiance on the retina if the focal length of the eye, from the cornea to retina, is equal to f = 1.7 cm. **8 + 5 + 7**

7. Write short notes on ***any four:*** **5 X 4**

i) Zero order system
ii) LED
iii) Laser protective eyewear
iv) Maximum permissible exposure
v) Irradiance of a diverging beam
vi) Radiation quantities