University of Technology
Department of Laser & Opto-electronic Engineering
Final Examination 2011-2012

Subject: Laser Applications — *Class:4th year*
Division: Laser Engineering — *Time:3 hours*
Examiner: Assist.Prof.Dr.Mohammed.A — *Date:7 /6 /2012*

Answer five questions only

Q_{1A}: Summarize the main importance of laser when compared to conventional techniques for different applications. **(4 Marks)**

Q_{1B}: A laser printer has a quoted resolution of 600 dots per inch and a printing rate of 10(A4) pages per minute. If the exposure level required for the particular photosensitive drum used is 1.5μJ/cm^2 at the laser wavelength, what is the minimum laser power necessary if you know the area of (A4) page is (210×297) mm? **(8 Marks)**

Q_2: 1. By using an "Energy Balance" argument for laser welding, Show that the welding depth (d) may be written:

$$d = \frac{2P}{\pi\, r V_m \rho (C T_m + L_m)}$$

2. Use the derived expression in (1) to estimate the welding speed possible when welding two (1mm) thick iron plates together using (2kW) laser. Assume that the laser output is focused down to a spot of (1mm) diameter, assume surface reflectance of (0.5) Take the thermal constants as:

C = 449 J/Kg.K	ρ = 7870 Kg/m^3	Tm = 1810 K	Lm = 2.7x 10^5 J/Kg

(12 Marks)

Q_{3A}: Show that the particle velocity v (as a function of fringe separation) of dual beam laser Doppler velocimeter is given as:

$$v = \frac{\lambda\, \Delta v}{2 \sin(\theta/2)}$$

(6 Marks)

Q_{3B}: state the advantages and the disadvantages of optical alignment? **(6 Marks)**

(اقلب الصفحة رجاءاً)

Q_4: A noncooperative target with diameter d_{tar} = 0.2 meter and reflectivity 0.5 and the following parameters:

$P_t = 10$ kW

$\theta_t = 10^{-2}$ radians

$R = 10^3$ meters

$d_{ta} = 10$ cm

$d_{ra} = 10$ cm

$\lambda = 1.06 \times 10^{-4}$cm (Nd:YAG laser)

$T = 0.8$

Find the received power? (12 Marks)

Q_{5A}: What are the techniques in the laser tracking system? Explain it? (4 Marks)

Q_{5B}: Define thermal dose equation , and use it in determining thermal dose of the skin tissue , having the following temperature history during subjected to CW CO_2 laser:

time(s)	0	1	2	3	4	5	6
Temperature(°C)	37	40	43	46	50	60	65

Is the skin is necrosis or not? Assume that the threshold limit of necrosis for skin is 240 minutes. (8 Marks)

Q_6: Answer only <u>four</u> of the following: (12 Marks)

1. On what factors the interaction between electromagnetic radiation and biological tissue depend on.
2. What is the main advantage behind using photo ablation interaction between tissue and lasers.
3. What are the thermal changes in biological tissue as a result of laser action.
4. Some dental laser application used Er:YAG laser discuss the mechanism of interaction.
5. What is the difference between PRK versus LASEK?

(اقلب الصفحة رجاءً)

monitor continuously the position of new commercial aircraft during FAA qualifications.

The PATS consists of a Q-switched YAG laser illuminator and collimating optics, a number of retroreflector (or corner cube) tracking targets mounted on the aircraft, an angle-sensitive tracking receiver, and a servo-controlled pedestal that points the optical system at the target. Logarithmic amplifiers are used in the signal-processing circuitry to allow the system to accommodate large differences in received power.

(2) Laser Ranging and Tracking at White Sands Missile Range

A continuous laser tracking system based on an argon laser has been used at White Sands Missile Range in New Mexico to track missiles from launch. The 5-watt laser is fixed in position and the beam is moved by a piezoelectric deflection system. The beam tracks the nose cone of the missile, and is kept centered on the nose cone. The angular tracking is performed with an image-dissector tube. The range information is obtained by beam modulation telemetry through sinusoidal modulation of the laser beam

Q5B:

$$T.D = \int_0^t R \, dt \qquad (T-43)$$

$R = 4 \quad 73 < T \leq 43$

$R = 2 \quad T \geq 43$

$$F.D = 4^{\left(\frac{40+37}{2} - 43\right)} \times 1 + 4^{\left(\frac{43+40}{2} - 43\right)} \times 1$$

$$+ 2^{\left(\frac{46+43}{2} - 43\right)} \times 1 + 2^{\left(\frac{50+46}{2} - 43\right)} \times 1$$

$$+ 2^{\left(\frac{50+60}{2} - 43\right)} \times 1 + 2^{\left(\frac{65+60}{2} - 43\right)} \times 1$$

$$= \frac{1}{4^{4.5}} + \frac{1}{4^{1.5}} + 2^{1.5} + 2^{5} + 2^{12} + 2^{14.5}$$

$$= \frac{1}{512} + \frac{1}{8} + 2.83 + 32 + 4096 + 741455.2$$

$$= \frac{745586.1571}{60} = 12\,426.4 \text{ minute}$$

then the cell is necrosis.

since T.D > 240 minute

حلول أسئلة تطبيقات الليزر
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نموذج رقم (١)

Q4

because $\theta_t R >> d_{ta}$

so

$$P_r = P_t Y d_{ra}^2 \, d_{tar}^2 T^2 / 8 R^4 \theta_t^2$$

$$P_r = \frac{10^4 \times 0.5 \times (0.1)^2 \times (0.2)^2 \times (0.8)^2}{8 \times (10^3)^4 \times (10^{-2})^2} \text{ watts}$$

where all distances are in meters.

This gives $P_r = 1.6 \times 10^{-9}\ W$ as the power received back near the transmitter.

Q5A

techniques in the laser tracking system are

(1) Representative Angle-tracking Systems
(2) Laser Ranging and Tracking at White Sands Missile Range

(1)Representative Angle-tracking Systems

With the techniques described above, it is possible to construct sophisticated tracking systems for a wide variety of applications. We will describe a representative system.

The Precision Aircraft Tracking System (PATS) is an electro-optical tracking system developed to provide range and angle information for a moving target. The system has been used to

the Er:YAG laser was introduced to dental applications . The wavelength of the Er:YAG laser at 2940nm matches the resonance frequency of the vibrational oscillations of water molecules contained in the teeth. Thereby, the absorption of the Er:YAG radiation is strongly enhanced, resulting in a high efficiency. However, the sudden vaporization of water is associated with a pressure gradient. Small micro-explosions are responsible for the break-up of the hydroxyapatite structure. The coincidence of thermal (vaporization) and mechanical (pressure gradient) ablation effects has led to the term "thermomechanical interaction"

5) What is the difference between PRK versus LASEK?

Although PRK and LASEK use basically the same technique, there are minor differences between them. In PRK, epithelium is removed and the outermost layer below the epithelium is treated with laser. In LASEK, epithelium is not removed, but an alcoholic solution is used to cause the epithelial cells to weaken; the surgeon will fold the epithelial layer out of the laser treatment field, and fold it back in its original place after cornea has been reshaped by laser If the epithelial flap is not strong enough to be laid back in its original place, it will be removed, and the LASEK procedure becomes a PRK procedure.

حلول
تطبيقات الليزر

Q6:

1) On what factors the interaction between electromagnetic radiation and biological tissue depend on.
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1. The wavelength of light, which determines the energy of each photon of light.
2. The intensity of radiation (energy delivered).
3. The shape of irradiation (continuous or pulsed).
4. Spatial nature of the beam (focused or unfocused).

2) what is the main advantage behind using plasma induced ablation interaction between tissue and lasers.

A free electron is accelerated by the intense electric field in the vicinity of a focused laser beam. When this very energetic electron collides with a molecule, it

gives up some of its energy to the molecule. When sufficient energy is transferred, a bound electron is freed, and a chain reaction of similar collisions is initiated, resulting in a plasma: a soup of ions and free electrons. One applications of this is in lens capsulotomy to treat secondary cataracts

When obtaining power densities exceeding 10^{11} W/cm^2 in solids and fluids – or 10^{14} W/cm^2 in air – a phenomenon called optical breakdown occurs. By means of plasma-induced ablation, very clean and well-defined removal of tissue without evidence of thermal or mechanical damage can be achieved when choosing appropriate laser parameters

3)What are the thermal changes in biological tissue as a result of laser action.

1. Body temperature till 60°C: Tissue becomes warm, and it is possible to weld blood vessels.
2. 60-65°C: Coagulation.
3. 65-90°C: Protein Denaturalization
4. 90-100°C Elimination of fluids (Drying).
5. 100+°C: Vaporization and carbonization

4) Some dentail laser application used Er:YAG laser discuss the mechanism of interaction.