Kopi av Cover Page

Department of Physics
Examination paper for TFY4195 Optics (Optikk)
Examination date: 2020-12-05
Examination time (from-to): 09.00 – 13.00
Permitted examination support material: All support material is allowed
Academic contact during examination: Prof. Mikael Lindgren
Phone: 41466510

Technical support during examination: Orakel support services
Phone: 73 59 16 00

OTHER INFORMATION
If a question is unclear/vague – make your own assumptions and specify in your answer the premises you have made. Only contact academic contact in case of errors or insufficiencies in the question set.

Saving: Answers written in Inspera are automatically saved every 15 seconds. If you are working in another program remember to save your answer regularly.

Cheating/Plagiarism: The exam is an individual, independent work. Examination aids are permitted. All submitted answers will be subject to plagiarism control. *Note that the multiple choice questions are automatically scrambled so the question sets will be different to each student.*

Notifications: If there is a need to send a message to the candidates during the exam (e.g. if there is an error in the question set), this will be done by sending a notification in Inspera. A dialogue box will appear. You can re-read the notification by clicking the bell icon in the top right-hand corner of the screen. All candidates will also receive an SMS to ensure that nobody misses out on important information. Please keep your phone available during the exam.

Weighting and points: How the questions exactly are weighted should be shown on the at each question automatically in Inspera. Typically, the multiple choice/pairing questions gives 2 - 3p for each correct answer. There are no negative points. The total number of points will be normalized to 100 (%) and graded with the scale for A, B, C, etc as outlined by NTNU recommendations.

1 Kopi av 30 free points - write here

With a few sentences please indicate what you thought about this years version of the course, specifically around these issues:

How do you find assignments using computer as a part of the pensum? Should it be more/less of them?

Total workload. Do you feel the content was appropriate for a basic course in optics? Anything missing, in that case what?

How did the problem solving/assignments/labs balance in terms of workload? Pls indicate approximately how many hours /week you had to devote to the course on average throughout the semester.

Fill in your answer here

Format

Words: 0

Maximum marks: 30

2 Kopi av MC8 TFY4195 H2020

A free electron laser can generate very bright light in the extreme UV, that is, with very short wavelengths. A design criteria was initially to reach a wavelength of 1Å (10^{-10} m). What is the corresponding energy for such a generated photon given in electron volts (eV) ?

Select one alternative:

- 12.4 keV
- 4140 eV
- 12.4 eV
- 6.20 keV
- 1240 eV

Maximum marks: 3

3 Kopi av MC7 TFY4195 H2020

A box of matches is placed 20 cm to the left of a positive lens of focal length 15 cm and diameter 7.5 cm. Using a screen Erna is attempting to obtain an image of the box by shining light on it. What is true about the image of the match box?

Select one alternative:

- There is a virtual, erect, magnified image to the right of the lens.
- There is a real, inverted minified image 60 cm to the left of the lens.
- There is an real, inverted, magnified image 60 cm to the right of the lens.
- There is no image
- There is a non-magnified, real image at the focal plane, to the left of the lens.

Maximum marks: 3

4 Kopi av MC10 TFY4195 H2020

6 different electromagnetic waves propagating in the z-direction have each two electric components, E_X and E_y, as indicated in the column to the left. Pair each of the combination with the polarization state it represents.

Please match the values:

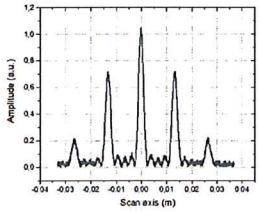
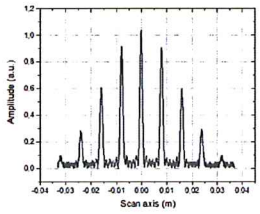
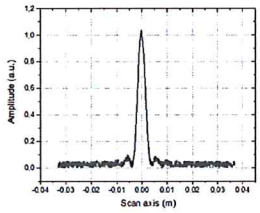
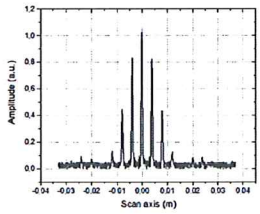
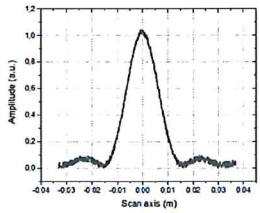
	Linear polarization	Circular polarization	Elliptical polarization
$\bar{E}_x(z,t) = 4.6\cos(kz-\omega t)\hat{x}$ [V / m] $\bar{E}_y(z,t) = 4.6\sin(kz-\omega t)\hat{y}$ [V / m]	○	○	○
$\bar{E}_x(z,t) = 2.3\cos(kz-\omega t+\pi)\hat{x}$ [V / m] $\bar{E}_y(z,t) = 4.6\cos(kz-\omega t)\hat{y}$ [V / m]	○	○	○
$\bar{E}_x(z,t) = 2.3\cos(kz-\omega t+\pi/4)\hat{x}$ [V / m] $\bar{E}_y(z,t) = 2.3\cos(kz-\omega t-\pi/4)\hat{y}$ [V / m]	○	○	○
$\bar{E}_x(z,t) = 4.6\cos(kz-\omega t-\pi/2)\hat{x}$ [V / m] $\bar{E}_y(z,t) = 4.6\sin(kz-\omega t)\hat{y}$ [V / m]	○	○	○
$\bar{E}_x(z,t) = 2.3\cos(kz-\omega t)\hat{x}$ [V / m] $\bar{E}_y(z,t) = 4.6\cos(kz-\omega t+\pi/2)\hat{y}$ [V / m]	○	○	○
$\bar{E}_x(z,t) = 2.3\cos(kz-\omega t-\pi/3)\hat{x}$ [V / m] $\bar{E}_y(z,t) = 4.6\cos(kz-\omega t+\pi/4)\hat{y}$ [V / m]	○	○	○

Maximum marks: 18

5 Kopi av MC6 TFY4195 H2020

Odrun is developing a new student lab in Optics and got some predefined slits to try to record diffraction patterns with. She has a green 532 nm laser of high coherence giving a parallel beam, and places the slit pattern right before a lens with focal length 75 cm. In the focal plane he then studies the diffraction patterns by scanning a detector to record the intensity distribution as a function of position. He is testing a series of slits with specifications as given with the 5 text entries along the row below. Pair what slit variant gave what diffraction pattern (i.e., to the plots arranged vertically).

Please match the values:

	6 slits 0.01 mm wide, separated 0.05 mm	5 slits 0.01 mm wide, separated 0.03 mm	Single slit, 0.025 mm	6 slits 0.025 mm wide, separated 0.1 mm	Single slit 0.1 mm wide
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○
	○	○	○	○	○

Maximum marks: 15

6 Kopi av MC5 TFY4195 H2020

A left-circularly polarized light-wave is propagating within a glass of refractive index 1.73 and hits a planar inner surface with air on the outside. The angle of incidence is 60^{o}. What can you say about the reflected and/or transmitted light?

Select one alternative:

- All light is reflected
- The transmitted light is circularly polarized.
- The reflected light is unpolarized.
- All transmitted light is linearly polarized.
- No light is reflected.

Maximum marks: 3

7 Kopi av MC11 TFY4195 H2020

Visible light (400 - 700 nm) is to be normally incident onto a transmission grating using a lens of focal length 25 cm to direct the diffracted light. There are two gratings of equal widths to choose from. The first grating (G1) has a groove separation of 2.5×10^{-6} m. The second grating (G2) has half as many grooves/mm. Indicate the choice of grating for each statement:

Statement A: The grating having the smallest angular dispersion for the second order diffraction order, for any given wavelength within the free spectral range?

Statement B: The grating having the highest resolving power for the first diffraction order?

Please select the correct alternative

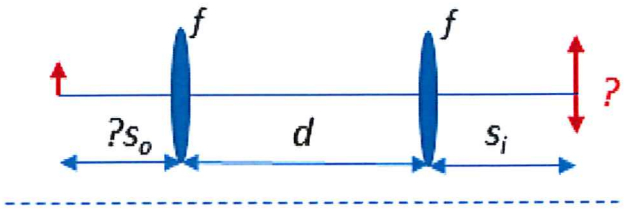
	G2	G1
Statement A	○	○
Statement B	○	○

Maximum marks: 4

8 Kopi av MC13 TFY4195 H2020

An optical imaging system consisting of two equivalent positive lenses separated by some distance d is defined by a system ray-transfer matrix M_{sys} as shown below. As indicated, also the distance to the image plane is included in M_{sys}. What is the distance of the object to the first lens, and what is the magnification and nature of the image? (Unit for distances is cm.)

$$M_{sys} = M_{s_i} M_f M_d M_f = \begin{pmatrix} 2 & -14 \\ 1/2 & -3 \end{pmatrix}$$



Convention for ray-transfer matrices

$$M_f = \begin{pmatrix} 1 & 0 \\ -1/f & 1 \end{pmatrix} \qquad M_d = \begin{pmatrix} 1 & d \\ 0 & 1 \end{pmatrix}$$

thin lens *translation*

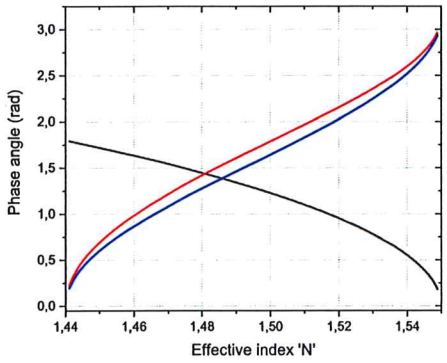
Select one alternative:

- s_o = 7 cm; a real, erect image, magnified x 0.5.
- s_o = 7 cm; an erect, real image, magnified x2.
- s_o = 14 cm; an inverted, real image, magnified x2
- s_o = 14 cm; a virtual, inverted image, magnified x0.5.

Maximum marks: 3

9 Kopi av MC14 TFY4195 H2020

The plot below shows the mode dispersion for TE and TM modes of a planar slab waveguide. The top and lower cladding layers have refractive index 1.44 whereas the center guiding layer has refractive index 1.55. The wavelength is 800 nm and the guiding layer has a thickness $0.4\mu m$.



What statement is most correct for the phase velocities (v) of the allowed propagating modes?

Select one alternative:

- $v_{TE} > v_{TM}$; $\approx 2 \cdot 10^8 m/s$
- $v_{TE} > v_{TM}$; $\approx 3 \cdot 10^8 m/s$
- $v_{TE} < v_{TM}$; $\approx 2 \cdot 10^8 m/s$
- $v_{TE} < v_{TM}$; $\approx 3 \cdot 10^8 m/s$

Maximum marks: 3

10 Kopi av MC9 TFY4195 H2020

A lens has two convex surfaces with radius of curvature 0.15 and 0.10 m, respectively. The glass has a refractive index of 1.50. What is the corresponding focal length taking into account that the paraxial approximation and the thin lens law apply.

Select one alternative:

- 0.6 m
- 12 cm
- 25 cm
- 0.15 m
- 0.10 m

Maximum marks: 3

11 Kopi av MC4 TFY4195 H2020

Unpolarized light is impinging on a glass surface of refractive index 1.73 with the incident angle 60^{o}. What can you say about the light transmitted through the surface?

Select one alternative:

- No light is reflected.
- Both the transmitted and reflected light is circularly polarized.
- Essentially all transmitted light is linearly polarized parallel to the surface.
- Essentially all transmitted light is circularly polarized.
- Essentially all transmitted light is linearly polarized in the plane of incident.

Maximum marks: 3

12 Kopi av MC2 TFY4195 H2020

Petter has a white light source and wants to use it in a Michelson interferometer experiment set-up using green light ($\lambda = 550nm$). He finds a 10 nm pass-band i.e., a filter that transmits light between 545 and 555 nm. What is the approximate coherence length of such a wavelength filtered light source?

Select one alternative:

- $l_c = 3.0\mu m$
- $l_c = 0.3mm$
- $l_c = 30\mu m$
- $l_c = 55nm$
- $l_c = 550\mu m$

Maximum marks: 3

13 Kopi av MC12 TFY4195 H2020

Two different positive lenses separated some distance has the following system matrix:

$$M_{sys} = \begin{pmatrix} -1/4 & 25 \\ 0 & -4 \end{pmatrix}$$

. What is the most likely function of the optical system.

Ray-transfer matrices for a positive thin lens and a translation are defined as follows:

$$M_f = \begin{pmatrix} 1 & 0 \\ -1/f & 1 \end{pmatrix}$$

$$M_d = \begin{pmatrix} 1 & d \\ 0 & 1 \end{pmatrix}$$

Select one alternative:

- An autofocus system with magnification = 1.
- A compound microscope with magnification 4.
- An eye-piece (ocular) with magnification 1/4.
- A telescope with angular magnification 4

Maximum marks: 3

14 Kopi av MC3 TFY4195 H2020

Using the green light source in problem MC6 ($\lambda = 550nm$), Victoria wants to test the classical double-slit experiment. As she knows about spatial coherence she puts a lens to focus the light onto a small pinhole (a thin circular aperture) which is $250\mu m$ in diameter. The light passing through the pinhole is then used for the interference experiment using a sensitive photon counting detector. The double slit is placed 25 cm from the pinhole. What is the maximum width between the slits she can examine without running into problems related to the spatial coherence?

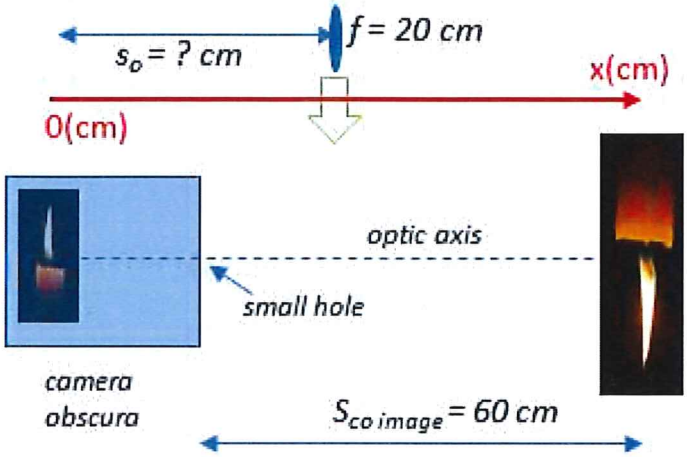
Select one alternative:

- $6.7mm$
- $670\mu m$
- $67\mu m$
- $6.7nm$
- $670nm$

Maximum marks: 3

15 Kopi av MC1 TFY4195 H2020

Angelica is attempting to reproduce some of the imaging experiments demonstrated on the optics lectures using a candle in a dark room. She first set up the *camera obscura* experiment with the candle inside a box having a small pinhole, to form an image 60 cm away (from the pinhole) on the wall, as shown in the picture. At this distance, the image of the burning flame is twice as big as the flame itself. Now removing the box constituting the camera, she wants to create an image of the same appearance (size, orientation) on the wall. Where should she place a lens of focal length 20 cm along the optic axis to achieve this? (n.b. the cartoon is not to scale)



Select one alternative:

- 45 cm
- 40 cm
- 30 cm
- 15 cm
- 60 cm

Maximum marks: 3