

Opti 415/515 Homework #3

#1) – For tables of Zernike polynomials in rms normalized, doubly indexed form, see for example ISO24157, annex E.

a) A surface is measured by a Fizeau interferometer having a known reference wavefront error specified by the Zernike coefficients r_n^m . The measured wavefront is described by the set of Zernike coefficients w_n^m . The surface is represented by a set of Zernike coefficients s_n^m . Express s_n^m in terms of r_n^m and w_n^m and explain your answer in one sentence.

b) A wavefront has tilt in both the x and y directions specified by the Zernike coefficients $b_1^{-1} = 3$ and $b_1^1 = 4$. What is the magnitude and direction of the tilt? You should not need a calculator to do this problem.

c) A wavefront has astigmatism described by the Zernike coefficients $a_2^{-2} = 1$ and $a_2^2 = 1$. What is the magnitude and direction (angle) of the astigmatism?

#2) Design a shear plate for use in collimating a 50 mm diameter beam of Green HeNe light. Use N-BK7 for the plate. Choose a plate thickness and wedge angle to optimize the performance of the shear plate for collimation testing. How sensitive is your design to focus error. Justify your answer.

#3) You are building a fixture to be used in an alignment process. A spherical mirror must be positioned so that its center-of-curvature is coincident with the center of a 1/2" tooling ball.

a) Describe the procedure for doing this with an autostigmatic microscope.

b) Select an objective from Edmund Optics for use on your autostigmatic microscope. Assume your autostigmatic microscope is an infinite conjugate design with a uniformly illuminated, 7 mm diameter beam, 635 nm light source, 100 mm focal length tube lens and a camera with 4.65 μm square pixels.

c) How well can you locate the center of the tooling ball (estimate the uncertainty in all directions)?

d) How well can you locate the center-of-curvature of the mirror (estimate the uncertainty in all directions)?

e) Look at the Newport catalog and identify a set of stages and actuators for positioning the PSM consistent with the performance you have described.

f) You have access to a phase shifting Fizeau interferometer (Zygo XP/D) operating at 632.8 nm with an F/3.3 transmission sphere that can be used in place of the autostigmatic

microscope. Estimate the uncertainty in locating the center-of-curvature of the tooling ball and mirror with the Fizeau interferometer

g) Pick an instrument for the task and justify your choice.

4) undergrads one of 4a, 4b, or 4c req'd, additional for extra credit / grad all reg'd

a) Sketch the layout and describe the operating principle of a scatterplate interferometer. What is the critical property of the scatterplate? What are the pros and cons of this instrument? What is its best application?

b) Sketch the layout and describe the operating principle of a point diffraction interferometer. What are the pros and cons of this instrument? What is its best application?

c) Most commercial interferometers use linearly polarized light, but the new “instantaneous” phase measuring interferometers typically use circularly polarized light. Under what circumstances does an instantaneous phase measuring interferometer make sense to use? Under what circumstances does a more classical instrument make sense (i.e. one that does temporal phase shifting rather than spatial)?

5) Shack cubes were originally designed in the era of film cameras, and were typically used with 35 mm film cameras which have a 24 mm x 36 mm image plane and the cubes were typically about 1” on a side.

Where is the point source located in a Shack cube interferometer, and why?

Is it always necessary to use a lens between the cube and detector?

Sketch the first order layout for your interferometer, with dimensions, to test a 200 mm diameter, 400 mm vertex radius spherical mirror from its center of curvature.

Can you phase shift this interferometer? If yes, describe briefly how to do so.

