GÖTEBORGS UNIVERSITET

Optical Tweezers and Optical Manipulation, 5.0+5.0+5.0 hp

Course period:	Last day for application:
January 2018 – December 2018	January 20, 2018

Course leader / Address for applications:
Giovanni Volpe / giovanni.volpe@physics.gu.se

Course description (Advertisment for Ph.D. students):

An optical trap (or optical tweezers) is generated by focusing a laser beam to a tiny spot. The high intensity in this tiny spot is able to attract and trap small (microscopic) particles present in solution, such as living cells and small colloidal particles. In recent years, optical traps have been more and more widely used in various sub-disciplines within physics and biology. For example, optical tweezers have been employed to measure the small forces (in the range of piconewton down to femtonewton) generated by biomolecules (e.g. the force required to pull a DNA strain), by microorganisms (e.g. the attachment force between a bacterium and a substrate), and by viruses (e.g. the force required to pack the virus DNA into its capsid). Optical tweezers have also been employed to study the properties of matter on microscopic scales and to study statistical physics.

The course will take place over 2018 and the timetable will be flexible. The course will comprise three parts (each 5.0 hp):
(1) Theoretical background on optical manipulation, including the theory of optical trapping in the geometrical optics and dipole-approximation regimes. [January–March: 3 lectures; self-study; take-home problem sets]
(2) Review of application of optical trapping with extensive review of the literature and a focus on applications in colloidal physics, soft matter, statistical physics, and biophysics. [April–June: biweekly group presentations]
(3) Laboratory work consisting of the realization and operation of an optical tweezers setup and the realization of an experiment. Where possible and desirable, the laboratory work can be focused on a project related to the research field of the students. [June–December: lab group work; final report]

The course will be complemented with a 3-5 day workshop in June featuring several international scientists working in optical trapping and related fields.

Responsible department and other participation departments/organisations:
Department of Physics

Teacher:
Dr. Giovanni Volpe

Examiner: Dr. Giovanni Volpe

GÖTEBORGS UNIVERSITET
Faculty of Science; Department of Physics

GÖTEBORGS UNIVERSITET

Optical Manipulation, 5.0+5.0+5.0 hp

Third cycle education

---

1. Confirmation
The syllabus was confirmed by the Head of the Department of Physics 2017-10-03.

Disciplinary domain: Science
Department in charge: Physics

2. Position in the educational system
Elective course; third-cycle education.

3. Entry requirements
Students should have a self-motivated interest in optical trapping and optics.

4. Course content
This course is dividend in three modules focusing on the theoretical and experimental understanding of optical trapping and optical manipulation techniques. Specific topics that are included are:
(1) Theoretical background on optical manipulation, including the theory of optical trapping in the geometrical optics and dipole-approximation regimes.
(2) Review of application of optical trapping with extensive review of the literature and a focus to applications in colloidal physics, soft matter, statistical physics, and biophysics.
(3) Laboratory work consisting of the realization and operation of an optical tweezers setup and its use for an experiment.

5. Outcomes
After completion of the course the student is expected to be able to:

Knowledge and understanding
* Read and understand the scientific literature in optical trapping and optical manipulation.
* Describe the design of an optical tweezers.

Skills and abilities
* Calculate optical forces within the geometrical optics and dipole-approximation regimes.
* Build an optical tweezers.
* Operate an optical tweezers.
* Optimize an optical tweezers for applications in soft matter, biophysics, statistical physics and colloidal physics.

Judgement and approach
* Critically analyse published results in optical trapping and optical manipulation.

6. Required reading
Jones, PH, OM Maragò & G Volpe (2015). *Optical Tweezers: Principles and Applications.* Cambridge University Press, Cambridge, United Kingdom.

Further reading materials will be provided eight weeks before the course start.

7. Assessment
Student evaluations will be based on: (1) participation in course lectures, (2) completion of course exercises; and (3) completion of laboratory mini-projects.

Students will be given pass/fail marks.

8. Grading scale
The grading scale comprises Fail, (U), Pass (G)

9. Course Evaluation
The course evaluation is carried out together with the Ph.D. students at the end of the course, and is followed by an individual, anonymous survey. The results and possible changes in the course will be shared with the students who participated in the evaluation and to those who are beginning the course.

10. Language of instruction: The language of instruction is English.