THE UNIVERSITY OF SYDNEY

School of Physics

PHYS 1901 Physics 1A (Advanced) – Semester 1, 2017

Module 1 – Mechanics

This module is one of three comprising PHYS 1901 Physics 1A (Advanced). This document describes details of this module and should be read in conjunction with the *Unit of Study Outline* for PHYS 1901 Physics 1A (Advanced).

GENERAL GOALS OF THIS MODULE

You will firstly investigate the causes of changes in the state of motion — a field of physics called *dynamics* — in particular to understand the basis and application of Newton's laws of motion. You will also relate the ideas of Newtonian dynamics to the concepts of work and energy, and the laws of conservation of energy and momentum. These concepts will then be used to explore rotational dynamics and the parallels between the descriptions and dynamics of rotational and straight-line motion. The module concludes with an examination of the universal gravitational force. This module will extend your current knowledge of mechanics using powerful vector-calculus methods that will simplify your further studies of mechanics and other areas of physics.

MODULE DEFINITION – MECHANICS

Specified as references from the text: *University Physics (with Modern Physics)* by Young and Freedman, 14th edition. (Section numbers are the same in the 13th edition).

ASSUMED KNOWLEDGE AND REVIEW

The first three chapters of the textbook are considered to be review material for this module. Students interested in doing preliminary reading should cover sections 2–1 to 2–5 and 3–1 to 3–4 in particular. The content of these chapters will be covered rapidly in class.

Chapter 1 UNITS, PHYSICAL QUANTITIES AND VECTORS

Text sections: 1 to 9 (Vector Product in Section 10 will be addressed in Chapter 10)

Chapter 2 MOTION ALONG A STRAIGHT LINE

Text sections: 1 to 5

Chapter 3 MOTION IN TWO OR THREE DIMENSIONS

Text sections: 1 to 5

SPECIFIC OBJECTIVES:

There is no easy road to learning. Your marks will depend on the work that you do. You should therefore read through and understand the sections of the textbook specified below, and work through the specified 'Text examples'. You should then attempt as many as possible of the MasteringPhysics questions. Problem solving skills can only be acquired by practice.

Chapter 4 NEWTON'S LAWS OF MOTION

Text sections: 1 to 6
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Define and apply the concepts of force, net force, mass and particle or point mass.
- Identify the forces on a body, particularly weight, normal force, frictional force, tension.
- Define and apply Newton's three laws of motion.
- Draw free-body diagrams and use them to assist with force problems.

Chapter 5 APPLYING NEWTON'S LAWS

Text sections: 1 to 4. Read 5 for interest.
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Define the concept of equilibrium for particles.
- Apply knowledge of Newton's laws to systems involving static frictional force, kinetic frictional force.
- Define and apply the coefficients of static and kinetic friction in force problems.
- Describe circular motion, in particular identify the force responsible for centripetal acceleration, and calculate properties of rotating systems.
- Calculate the resistance to motion due to the drag force from a fluid.

Chapter 6: WORK AND KINETIC ENERGY

Text sections: 1 to 4
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Define and calculate work and kinetic energy, and understand the relationship between them — the 'work-kinetic energy theorem'.
- Calculate the work done by variable forces, including systems that obey Hooke's law.
- Derive the relationships between different units of work: joule, electron volt, kilowatt hour.

Chapter 7: POTENTIAL ENERGY AND ENERGY CONSERVATION

Text sections: 1 to 5
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Define and calculate potential energy, in particular gravitational and elastic PE.
- Define the law of conservation of mechanical energy, and apply it to various dynamical systems.
- Describe the difference between conservative and non-conservative forces.
- Calculate the work done by frictional forces, and describe the concept of the amount of work done on a system by a force.
- Describe the relationships between force and potential energy, and use energy diagrams to calculate the dynamics of various systems (particular emphasis on this).

Chapter 8: MOMENTUM, IMPULSE AND COLLISIONS

Text sections: 1 to 6
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Define and calculate the linear momentum of a particle, the total linear momentum of a system and the relationship between impulse, force and momentum.
- Describe and apply the law of conservation of linear momentum.
- Describe the difference between internal and external forces.
- Describe inelastic and elastic collisions and apply the conservation laws appropriate in each case to examine collisions.
- Calculate the centre of mass for a system, and the motion of the centre of mass due to external forces.
- Apply conservation of momentum to variable-mass systems, including rocket propulsion.

Chapter 9: ROTATION OF RIGID BODIES

Text sections: 1 to 6
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Define the variables of angular motion: angular position, displacement, speed, velocity and acceleration.
- Describe and apply the relationships between linear and angular kinematics.
- Define the moment of inertia and calculate it for simple situations.
- Calculate the energy in systems undergoing rotational motion, including the rotational kinetic energy.
- Derive the Work–Kinetic Energy theorem for rotation.

Chapter 10: DYNAMICS OF ROTATIONAL MOTION

Text sections: 1 to 7
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Define and apply the concept of torque, particularly as a vector product (introduction of vector product).
- Apply the relationship between torque and angular acceleration of an object.
- Describe the dynamics of systems undergoing combined translation and rotation — rolling without slipping (not rolling friction).
- Calculate the work done by a torque (not power).
- Define and calculate angular momentum (as a vector quantity), and derive Newton's 2nd law for angular quantities.
- Describe and apply the law of conservation of angular momentum.
- Calculate the total angular momentum for a system of bodies.
- Apply the conservation of angular momentum to gyroscopes and precession.

Chapter 13: GRAVITATION

Text sections: 1 to 5
Text examples: Work through all

Specific objectives – after studying this chapter you should be able to:

- Describe and apply Newton's law of gravitation.
- Apply the superposition of gravitational fields to systems of more than two particles.
- Calculate the gravitational potential energy in a variety of systems.
- Apply Newton's law of gravitation to calculate the orbits of satellites
- Derive Kepler's laws of planetary motion.

