DEPARTMENT OF PHYSICS

NELSON MANDELA UNIVERSITY

STUDY GUIDE

for

Course PHYV101

Physics 1A for Engineers

Mechanics & Physical Properties of Matter

Our Module material is on Moodle at

https://funda.mandela.ac.za/course/view.php?id=1171

Presented by: Dr. David Waswa

MECHANICS

GOAL OF THE COURSE

To acquire skills regarding:

a) The prediction of motion of any object moving in a straight line, or in a plane or in a circle, or that performs harmonic motion.
b) The mechanics of fluids.

COURSE CONTENT

Chapter 1: Units and Measurements
Chapter 3: Vectors
Chapter 2: Motion along a Straight Line
Chapter 4: Motion in a Plane
Chapter 5: The Laws of Motion (Newton)
Chapter 6: Uniform Circular Motion
Chapter 7: Work and Energy
Chapter 8: The Conservation of Energy
Chapter 9: Momentum and Collisions
Chapter 10: Motion of an Object about a Fixed Axis
Chapter 11: Angular Momentum and Torque
Chapter 12: Conditions for Equilibrium
Chapter 13: Oscillatory Motion
Chapter 14: Law of Universal Gravitation
Chapter 15: Fluid Mechanics
Chapter 16: Wave Motion
Chapter 17: Sound Waves
Chapter 18: Superposition And Standing Waves
Chapter 19: Temperature, Thermal Expansion and Ideal Gases
Chapter 20: Heat and the First Law of Thermodynamics

PRESCRIBED TEXTBOOK

Physics for Scientists and Engineers (9th Edition and above)

Authors: Serway & Jewett

Publisher: Thomson Brooks/Cole

SPECIFIC GOALS

After completion of this part of the course, you would be able to:

Chapter 1 ***UNITS AND MEASUREMENTS***

(a) Know the values of prefixes of SI units.
(b) Do order of magnitude calculations.
(c) Solve problems on the above.

Chapter 2 ***VECTORS***

(a) Distinguish between vectors and scalars.
(b) Resolve vectors into components.
(c) Explain and use unit vectors.
(d) Calculate the resultant magnitude and direction of a number of vectors.
(e) Solve problems on the above.

Chapter 3 ***MOTION IN ONE DIRECTION***

(a) Define average and instantaneous velocity and acceleration.
(b) Have insight into differentiation, and to know the physical meaning thereof.
(c) Derive the equations of motion for an object moving in one direction with constant acceleration from the basic definitions of acceleration, velocity and displacement.
(d) Derive equations of motion for free falling objects and to apply these equations.
(e) Solve problems on the above.

Chapter 4 ***MOTION IN A PLANE***

(a) Realise that motion with constant acceleration in a plane is similar to two independent motions in the x and y directions.
(b) Obtain equations of motion for movement in a plane from the equations of motion applicable to motion in a straight line.
(c) Obtain expressions for the components of velocity and for the position coordinates of a projectile.
(d) Derive an expression for uniform circular (centripetal) acceleration of an object.
(e) Solve problems on the above.

Chapter 5 ***LAWS OF MOTION***

(a) Know Newton's laws of motion.
(b) Distinguish between mass and weight.
(c) Define the inertia of an object.
(d) Draw force diagrams for objects upon which several forces are acting.

(e) Define the coefficients of static and kinetic friction.
(f) Know that forces of friction are proportional to the normal force on an object.
(g) Define the normal force.
(h) Apply Newton's laws to any mechanical system by:
    i) being able to identify external forces
    ii) drawing force diagrams
    iii) applying Newton's 2nd law
(i) Solve problems on the above.

Chapter 6 ***UNIFORM CIRCULAR MOTION***

(a) Analyse motion in a circular path by employing Newton's laws.
(b) Solve problems on the above.

Chapter 7 ***WORK AND ENERGY***

(a) Define the work done by an external force on an object.
(b) Have gained knowledge of the scalar product of vectors, and be able to apply the knowledge.
(c) Derive an expression for the work done by a varying force.
(d) Know Hooke's law.
(e) Determine the work done to extend a spring.
(f) Define kinetic energy.
(g) Derive the work-energy theorem.
(h) Define power.
(i) Solve problems on the above.

Chapter 8 ***CONSERVATION OF ENERGY***

(a) Define: (i) conservative forces (ii) potential energy.
(b) Discuss (5 sentences) or define the conservation of mechanical energy.
(c) Derive the potential energy associated with gravity.
(d) Determine the work done by a non-conservative force.
(e) Derive the potential energy stored in spring.
(f) Solve problems on the above.

Chapter 9 ***LINEAR MOMENTUM AND COLLISIONS***

(a) Define: (i) linear momentum (ii) impulse (iii) a collision (iv) elastic and inelastic collisions.
(b) Obtain the relationship between the resultant force on an object and the rate of change of linear momentum.
(c) Use the conservation of momentum to solve problems.
(d) Solve problems on the above.

Chapter 10 ***ROTATION ABOUT A FIXED AXIS***

(a) Define average and instantaneous angular velocity and angular acceleration.
(b) Convert degrees to radians, and conversely.
(c) Know that each particle in an object rotating about a fixed axis has the same angular velocity and angular acceleration.

(d) Obtain equations of motion for an object undergoing rotational motion from the equations of motion in a straight line.

(e) Derive relationships between linear and rotational motion (viz $v = r\omega$ and $a_t = r\alpha$).

(f) Solve problems on the above.

Chapter 11 ***ANGULAR MOMENTUM AND TORQUE***

(a) Define: (i) torque (ii) angular momentum.

(b) Have gained knowledge regarding the cross product of vectors and be able to apply the knowledge.

(c) Solve problems on the above.

Chapter 12 ***STATIC EQUILIBRIUM***

(a) State the conditions for static equilibrium.

(b) Apply these conditions to solve problems on equilibrium.

Chapter 13 ***OSCILLATORY MOTION***

(a) Derive equations for the position, velocity and acceleration of an object performing simple harmonic motion (SHM) by considering the relationships between SHM and uniform circular motion.

(b) Derive the equations of motion for SHM.

(c) Define concepts associated with SHM: amplitude, angular frequency, phase constant (phase angle), phase, period and frequency.

(d) Derive an equation for the energy of an object performing SHM.

(e) Solve problems on the above.

Chapter 14 ***LAW OF UNIVERSAL GRAVITATION***

(a) State the law of universal gravitation.

(b) Solve problems on the above.

Chapter 15 ***FLUID MECHANICS***

(a) Define:

(b) a fluid ii) density iii) pressure iv) specific gravity v) buoyant force vi) apparent weight

(c) Be familiar with the units in which pressure is measured, as well as how pressure is measured.

(d) Derive an equation for the pressure at any depth in a fluid.

(e) State Pascal's principle and be able to apply it.

(f) State Archimedes' principle and be able to apply it.

(g) Solve problems on the above.

PHYSICAL PROPERTIES OF MATTER

GOAL OF THE COURSE

An investigation of all aspects of
(a) wave motion, including the superposition of waves
(b) sound
(c) basic thermodynamics
with the aim of introducing the student to the concepts, and providing the necessary skills of the use and application of the theories.

COURSE CONTENT

- Oscillatory motion
- Wave motion
- Sound waves
- Superposition and Standing Waves
- Temperature, Thermal Expansion and Ideal Gases
- Heat and Transfer of Heat
- Laws of Thermodynamics

Specific Goals

After completion of the course, the student will be able to:

Chapter 16: WAVE MOTION (following on from Chapter 13 OSCILLATORY MOTION)

(a) Define a wave
(b) Distinguish between transverse and longitudinal waves
(c) Define: (i) amplitude (ii) wavelength (iii) period (iv) frequency (v) wave number (vi) angular frequency
(d) Know the physical meaning of all the terms contained in the expression describing a moving wave
(e) Obtain expressions for the transverse velocity and acceleration of a harmonic wave
(f) Derive an expression for the speed of a wave in a stretched string
(g) Describe the results when a wave pulse is reflected/transmitted at a boundary
(h) Derive an expression which predicts the rate of energy transfer by a harmonic wave in a stretched string, and to describe which factors play an important role in the energy transfer
(i) Solve problems on the above

Chapter 17: SOUND WAVES

(a) State an expression for the velocity of sound waves
(b) Define: (i) displacement amplitude (ii) pressure amplitude (iii) intensity of a sound wave
(c) Derive an expression for the pressure amplitude associated with a longitudinal wave
(d) Derive an expression for the intensity of a sound wave
(e) Derive expressions for the frequency observed in the case for the Doppler effect for:
    a. moving observer, stationary source (ii) stationary observer, moving source
(f) Define the mach number
(g) Solve problems on the above

Chapter 18: SUPERPOSITION AND STANDING WAVES

(a) Derive the superposition of two harmonic waves, and to discuss the interference which occurs
(b) Derive an expression describing a standing wave, and discuss the nodes and anti-nodes that occur
(c) Obtain an expression for the vibrational frequencies at which nodes occur in a string
(d) Explain the following terms: (i) fundamental frequency (ii) overtones (iii) harmonic series (iv) quality of sound (v) beats
(e) Discuss the phenomenon of resonance
(f) Obtain expressions for the possible vibrational frequencies that will occur for:
    i) a pipe open at both ends
    ii) a pipe closed at one end
(g) Solve problems on the above

Chapter 19: TEMPERATURE, THERMAL EXPANSION AND IDEAL GASES

(a) State the zeroth law of thermodynamics
(b) Define: (i) Kelvin (ii) a mole
(c) Convert temperature from Celsius to Fahrenheit, and inversely, as well as to Kelvin
(d) Define or obtain linear and volume coefficients of expansion
(e) State Boyle's, Charles' and/or Gay-Lussac's laws and the equation of state for ideal gases
(f) Solve problems on the above

Chapter 20: HEAT AND THE FIRST LAW OF THERMODYNAMICS

(a) Define: (i) heat (ii) heat capacity (iii) specific heat capacity (iv) latent heat
(b) Discuss the relations between heat and work
(c) State the first law of thermodynamics
(d) Derive the basic law of heat conduction
(e) Solve problems on the above