HAROLD WASHINGTON COLLEGE
MASTER SYLLABUS – COLLEGE CREDIT COURSE

1. TITLE, NUMBER, AND CLASSIFICATION:

Name of Course Physics 221, Mechanics & Heat
Department Name Physical Science
Number Code 077
Course Number 0221

2. COURSE TERM: 16 Week Semester

3. CREDIT AND CONTACT HOURS:

(i) credit hours 4 (ii) contact hours per week 6 (iii) types of activities

X Lecture/Discussion
X Lab
Clinical/Work Experience
Other

4. PREREQUISITES - if none check here ; otherwise describe below:

Grade of C or better in Mathematics 141 or above or, consent of Department Chairperson.

5. CATALOG DESCRIPTION - write below, as in current college catalog;

Foundations and concepts in Physics including elementary problems in Mechanics and heat. Writing assignments, as appropriate to the discipline, are part of the course. 2 lecture and 4 lab hours per week

6. STUDENTS FOR WHOM THE COURSE IS INTENDED:

Primarily for students in liberal arts, premedical, and/or technical curricula.

7. COURSE OBJECTIVES:

The course is to cover:

1. Measurement Systems
2. Motion in One Dimension
3. Vectors and Two Dimensional Motion
4. Dynamics
5. Work Energy
6. Momentum and Collisions
7. Rotational Kinematics
8. Rotational Dynamics
9. Solids and Fluids
10. Fluid Dynamics
11. Thermodynamics
12. Heat Flow
13. Laws of Thermodynamics

8. STUDENT LEARNING OUTCOMES

By means of written responses, drawing diagrams, and solving problems involving calculation, the student will demonstrate the ability to

1. use the mathematics of position, velocity and acceleration describing motion along a line; represent motion graphically; solve kinematics problems; describe free fall and solve free fall problems;

2. describe and use the basic properties of vectors (magnitude, direction, components); decompose a vector into components, and use components to calculate magnitude and direction; add and subtract vectors, both graphically and using components;

3. solve problems involving general motion in a plane described in terms of vectors, and projectile motion. Demonstrate an understanding of the independence of perpendicular directions in projectile motion; solve problems involving relative velocity and acceleration;

4. define force in physical terms; describe the actions of the four fundamental forces; describe how contact forces arise from electrical interactions; identify the forces acting on a body and draw a free body diagram for it; describe the relation between the net force acting on a body, its velocity and its acceleration;

5. recognize and solve dynamic equilibrium problems along a line applying Newton's first law; recognize and solve dynamics problems along a line applying Newton's second law; describe the difference between mass and weight, and calculate apparent weight; solve dynamics problems involving friction, including the use of coefficients of friction;

6. solve dynamics problems involving uniform circular motion, including demonstration of knowledge of the magnitude and direction of the acceleration of a body in uniform circular motion; solve dynamics problems involving circular orbits; demonstrate an understanding of real and fictitious forces in circular motion, including apparent weight and the non-existence of centrifugal force.;

7. identify action-reaction pairs of forces on interacting bodies; solve dynamics problems involving action-reaction pairs of forces; solve dynamics problems involving tension and pulleys.

8. use Newton's law of gravity to calculate gravitational forces on bodies and the accelerations they cause; use Newton's law of gravity to solve dynamics problems involving circular orbits;

9. identify the interacting objects that comprise a closed system; apply the principle of conservation of momentum in one and two dimensions to collisions, explosive events and other interactions;

10. explain the meaning of the principle of conservation of energy; calculate kinetic energy, gravitational potential energy near Earth's surface, and the elastic potential energy stored in a spring; apply the principle of conservation of energy to problems involving kinetic energy and the above forms of potential energy;

11. calculate gravitational potential energy at large distances from gravitating bodies; apply the principle of conservation of energy to problems involving kinetic energy and gravitational potential energy at large distances; explain the meaning of escape velocity, and calculate the escape velocity of a body from any point in the vicinity of any number of gravitating bodies;

12. define and calculate the scalar product of vectors, using magnitudes or components; calculate the work done by a constant force in one or two dimensions, and by a variable force in one dimension; calculate power delivered in these cases; state in mathematical form the relationship between work and potential energy;

13. calculate thermal energy developed by frictional forces, either directly, using the magnitude of frictional force, or indirectly, using the principle of conservation of energy; apply the relation between work and energy to problems involving work and all forms of energy encountered previously;

14. use the definitions of angular position, velocity and acceleration, the relations between them, and their connections to linear velocity and acceleration to solve rotational kinematics problems; calculate the position of the center of mass of a collection of point masses, and identify the center of mass position of uniform symmetric bodies;

15. define and calculate torque, including torque due to gravity on an extended body; calculate moments of inertia of bodies consisting of point masses;

16. use the definitions of torque, moment of inertia and angular acceleration, and the dynamical equation that relates them, to solve problems in rotational dynamics; solve problems involving equilibrium of extended bodies;

17. calculate rotational kinetic energy, both for rotation about a fixed axis and rolling motion, and apply the principle of conservation of energy in problems including rotational motion; describe angular velocity, torque and particle angular momentum as vector quantities. Calculate the angular momentum of a rotating rigid body; use the principle of conservation of angular momentum to solve problems involving rotating bodies and particles with angular momentum.

18. describe simple harmonic motion, and identify the functions that give the displacement of a body in simple harmonic motion. Identify or be able to calculate the amplitude, period, angular frequency and frequency of a harmonic oscillator;

19. calculate position at any time for a harmonic oscillator, and identify maximum values of displacement, speed and acceleration; calculate the angular frequency for harmonic oscillation of a mass on a spring. Apply the principle of conservation of energy to problems involving motion of a mass on a spring; calculate the period of a simple pendulum and use it in problems involving pendulum motion;

20. given appropriate data, calculate the decreased amplitude of a damped oscillator at any time; describe resonance, and identify the resonant frequency of a force driving a harmonic oscillator.

21. draw and interpret a phase diagram for a pure substance; use the ideal gas law in problems relating temperature, pressure, volume and mass of an ideal gas; describe adiabatic,

isothermal, isobaric and isochoric processes, and use these concepts in conjunction with the ideal gas law in problem solving;

22. relate thermal energy changes to the specific heat of a substance; use specific heats and latent heats of fusion and vaporization with the concept of thermal equilibrium to solve calorimetry problems;

23. relate the temperature of an ideal gas to the average kinetic energy of its molecules; relate the number of degrees of freedom of diatomic and polyatomic gases to their specific heats;

24. use the first law of thermodynamics to relate work, heat, and internal energy changes of a system such as an ideal gas;

Students will be required to demonstrate laboratory skills in a series of experiments by doing the following:

1. measuring quantities carefully and correctly, including units and uncertainties;
2. making calculations from data correctly, including uncertainties in results where required;
3. recording data and calculations in a clear and organized way, with notes that make their meanings clear;
4. carefully and correctly plotting required graphs, and obtaining quantitative results
5. from them;
6. organizing data, calculations, graphs, results and additional written work to clarify them into a clear and literate report on the experiment.

9. TOPICAL COURSE OUTLINE:

1. *Measurement Systems*- SI, British engineering, and cgs systems of measurement; Scientific notation, Significant figures, Dimensional analysis, Conversion of units.

2. *Motion in One Dimension*- Linear kinematic equations, Average vs. instantaneous values of velocity and acceleration, Graphical interpretation of motion, Freely falling bodies, "g".

3. *Vectors and Two Dimensional Motion*- Vector and scalar quantities; Vector addition, subtraction, and multiplication; Finding components of vectors quantities; resolution of vectors; Calculation of velocity and acceleration in two dimensions with initial velocity; Projectile motion, relative velocity.

4. *Dynamics*- Force, Newton's laws, Net force, Motion under the action of frictional forces, Equilibrium with concurrent forces, motion on an inclined plane, Two dimensional motion under the action of forces.

5. *Work Energy*- Work, Energy, Kinetic energy, Potential energy, Conservation of mechanical energy, conservative and nonconservative forces, Work- Energy theorem, Power, Work done by a variable force, Interpretation of the force - distance graph.

6. *Momentum and Collisions*- Momentum and impulse, Conservation of momentum in one and two dimensions, Elastic and inelastic collisions, The location of the center of mass, Conservation of momentum for a system of particles.

7. *Rotational Kinematics*- Angular displacement, velocity, and acceleration; Motion under constant angular acceleration, Relation of linear and rotational quantities, Centripetal acceleration and centripetal force, Newton's Law of Universal Gravitation, Gravitational potential energy, Kepler's laws, Escape velocity, Period of orbiting bodies.

8. *Rotational Dynamics*- Torque, Conditions for equilibrium for nonconcurrent forces, Calculation of moment of inertia, Torque and angular acceleration, Analogy of linear and rotational formulae, Acceleration of rolling bodies, Conservation of angular momentum.

9. *Solids and Fluids*- Ionic and covalent bonding in solids, metallic bonding; Young's, shear, and bulk moduli; Calculation of strain under stress, Density and pressure, Pressure in a free fluid, Pascal's principle, Absolute vs gauge pressure, Archimedes principle and buoyant forces, Surface tension and capillarity.

10. *Fluid Dynamics*- Laminar and turbulent flow, Equation of continuity, Bernoulli's equation, Calculation of velocity and pressure from Bernoulli's equation, Viscous flow, Reynolds number, Poiseuille's law, Stokes law.

11. *Thermodynamics*- Absolute and relative temperature scales, Calculation of thermal expansion in solids and liquids, Ideal gas laws, Boyle's and Charles' laws, Avogadro's number, Kinetic molecular theory of gases, Temperature and rms velocity of gas molecules.

12. *Heat Flow*- Calorie, Specific heat, Latent heat, Calculation of energy transfer with change of state. Evaporation and condensation, Relative humidity, Heat transfer by conduction, Heat transfer by convection, Heat transfer by radiation, Black body radiation.

13. *Laws of Thermodynamics*- Internal energy, Interpretation of the P-V graph, First law of thermodynamics; Isobaric, isovolumetric, and isothermal processes; Heat engines and the second law of thermodynamics, Reversible and irreversible processes, The efficiency of a Carnot engine, Entropy and disorder.

10. TEXTS AND MATERIALS USED: List of books and/or materials suggested for this course

Physics, 3rd Edition, James S. Walker, Pearson/Prentiss Hall, 2007,
Chapters 1-13 and 15-18.
Laboratory material provided by instructor.

11. AMOUNT OF WRITING REQUIRED:

Laboratory reports, short answer essay questions and explanations of problem situations.
One short paper.

12. METHODS OF EVALUATION: (Direct and indirect)
Tests, lab reports, quizzes and presentation of short paper.

13. AUTHORIZED SIGNATURE AND FILE DATE:
DEPARTMENT AND CAMPUS **Physical Science Department**
Harold Washington College

5/06