# PHYS 3053-Physical Mechanics II Autumn 2020 

## 1 Equations of Motion [*Reading Assignment]

1.1 Introduction
1.2 Forces of the Form $F(t)$
1.3 Forces of the Form $F(v)$
1.4 Dimensional Analysis
1.5 Forces of the Form $F(x)$

## 2 Harmonic Oscillator

2.1 Simple Harmonic Oscillator
2.2 Time translation invariance and linearity
2.3 Linear homogeneous ordinary differential equation
2.4 Forces of the form $\mathrm{F}=\mathrm{F}(\mathrm{v})$ revisited (HOMEWORK)
2.5 Energy in Harmonic Oscillator
2.6 Small Oscillations
2.7 Coupled Oscillators and Normal Modes
2.8 Matrix Formalism for Normal Modes

## 3 Lagrangian Dynamics

3.1 Introduction
3.2 The Lagrangian, the Action, and Hamilton's Principle
3.3 Calculus of Variations
3.4 Functional Derivatives
3.5 Back to Hamilton's Principle
3.6 More Degrees of Freedom
3.7 The Euler-Lagrange equation
3.8 Generalized Momenta and Generalized Forces
3.9 Symmetries and Conservation Laws
3.10 Noether's Theorem
3.11 Lagrange Multipliers
3.12 Constraints and Generalized Forces of Constraints

## 4 The Hamiltonian Dynamics

4.1 Hamiltonian and Hamilton Equations of Motion
4.2 The Hamiltonian and Energy
4.3 Advantages of Hamiltonian Formalism
4.4 The Hamiltonian and Quantum Mechanics
4.5 Quantum Mechanics and the Sum Over Paths

## 5 Conservation of Angular Momentum

5.1 Introduction: Torque and Orbital Angular Momentum
5.2 Effective Potential for a Central Force
5.3 Small Oscillations
5.4 Effective Potential, Lagrangian, and Hamiltonian
5.5 Orbit Equation and Eccentricity
5.6 Polar Equation of a Conic Section
5.7 Kepler's Laws
5.8 Rutherford Scattering

## 6 Particle Systems and Rigid Bodies

6.1 Many Particle System
6.2 Rotational Equation of Motion
6.3 Rigid Bodies and Static Equilibrium
6.4 Rotations of Rigid Bodies
6.5 Gyroscope and Precession
6.6 Moment of Inertia Tensor
6.7 Principal Moments of Inertia and Principal Axes
6.8 Impulses and Billiard Shots
6.9 Eigenvalues and Eigenvectors of Inertia
6.10 Euler equations
6.11 A Free Symmetric Top and Euler Angles
6.12 The Tennis Racket Theorem
6.13 Transformation to Moving Coordinate Frames
6.14 Fictitious Forces
6.15 Foucault's Pendulum

## 7 Classical Collision Theory

7.1 Galilean Transformation
7.2 Elastic Collisions
7.3 Inelastic Collisions

## $8 \quad$ Special Relativity

8.1 The Principles of the Special Relativity
8.2 Lorentz Transformation
8.3 Length Contraction
8.4 Time Dilation
8.5 The Twin Paradox
8.6 The Addition of Velocity
8.7 Relativistic Momentum and Energy
8.8 The Space-Time 4-vector
8.9 The Momentum-Energy 4-vector
8.1 The Metric Tensor in the Minkowski Space
8.11 Scalar Product of 4-vectors
8.12 Relativistic Dynamics

BONUS: The Cosmological Principle and Hubble Expansion

