

## Study Guide (Midterm II)

### 1. Additional Math Concepts

Vector calculation

Adding two vectors together:

Multiplying: Scalar (dot) product, (definition, calculation)

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z = |\vec{A}| |\vec{B}| \cos \varphi$$

### 2. Forces (continued after Midterm I):

A. Normal force and friction.

1. Directions of the normal forces and frictions.
2. Static friction and kinetic friction
3. What is the relation between friction and the normal force?

B. Force of Springs:

1. Hook's Law  $F = -kx$
2. What are the terms in hook's Law, e.g.  $x$ ,  $F$ ,  $k$  and how is the signs of those quantities assigned?.

C. Equilibrium state of multiple forces.

1. If there are multiple forces exerting on an object and the object is in rest or moving at constant velocity, **the total force is zero.**

D. Application of Newton's Laws:

1. System in rest (equilibrium require the total force is zero)
2. System in motion with acceleration needs to apply the Newton's second Law.

Examples: tilted surfaces, projectile objects, objects linked by strings.

### 7. Work and Energy:

A. Definition of work, power and kinetic energy. What are their units? Are they scalar or vector?

B. Work theorem:  $W = \Delta K = K_f - K_i$

C. How do we calculate work and kinetic energy?

1. Work done along by constant force,
2. Work done by a force which is not at the same direction of the displacement,
3. Work done by a varying force.
4. Special case, work done by gravitational force and spring force.

D. Potential energy:

1. Gravitational potential energy and spring (elastic) potential energy.

$$P_g = mgh, P_s = \frac{1}{2} kx^2$$

2. Conservative force and non-conservative force. (which is which?)

E. Conservation of mechanical energy.

1. In what situation, the mechanical energy is conserved?
2. How to draw the bar graph of energies of a question?

F. Applications of mechanical energy:

1. Finding out work from the force-position diagram
2. Using conservation of mechanical energy to find out velocities, height, compress (stretch) of springs, etc.

### 8. Momentum

Definition of momentum.