**PHYS-1050-01,02 Exam 3 review guide**

## Chapter 6 - Dynamics: Newton's Laws of Motion

Work is energy expended to move an object. Work done on an object is force on the object times the distance the object moves in the direction of the force. $W = F_{||}d$.
Energy can be defined as the ability to do work.
Work and energy are measured in Joules. 1 J = 1 kg $m^2/s^2$ = 1 N m.
Work and energy are scalars.
Kinetic energy is energy of motion. $KE = mv^2/2$.
Work-energy principle: the net work done on an object equals the change of its kinetic energy.
Potential energy is stored energy, which may be gravitational, elastic, chemical, etc.
Gravitational potential energy: $PE_G = mgy$, where $y$ is height.
For springs, Hooke's law gives force exerted by spring as $F = -kx$, where $k$ is spring stiffness constant. Potential energy stored in spring is $PE_{el} = mx^2/2$.
Total mechanical energy is sum of kinetic and potential energy. Total energy is same, but also add heat energy.
Conservative forces are those in which the work done does not depend on path taken (e.g. gravity, spring). They give rise to potential energy.
Non-conservative forces are those in which work done does depend on path taken (e.g. friction, pull or push by person). They do not give rise to potential energy.
Mechanical energy is conserved with conservative forces, while some is converted to heat for non-conservative forces.
Total energy is always conserved.
Power is rate at which work is done. $P = \Delta E/\Delta t$.
Power is measured in Watts. 1 W = 1 J/s = N m/s.
Starting from W = Fd, find that $P = Fv$.

## Chapter 7 - Linear momentum

Momentum is defined as $\mathbf{p} = m\mathbf{v}$, where $\mathbf{v}$ is velocity.
Momentum is a vector. It has units of kg m/s.
Newton's second law can be given as the change of momentum of an object over time equals the net force on the object, $\sum\mathbf{F} = \Delta\mathbf{p}/\Delta t$. If mass is constant, this simplifies to $\sum\mathbf{F} = \mathrm{m}\mathbf{a}$.
Momentum is conserved during collisions, even if energy is not (this is a consequence of Newton's 3rd law).
Conservation of momentum: the total momentum of an isolated system of objects remains constant.
Impulse, $\mathbf{J}$, is change of momentum. $\mathbf{J} = \Delta\mathbf{p} = \mathbf{F}\Delta t$.
Impulse is a vector. It has units of kg m/s, or N s.
Impulse is area under a force-time graph.
Inelastic collisions are those in which mechanical energy is not conserved. For example, if two objects arrive separately and become joined together, then kinetic energy is

converted to heat. Alternatively, if one object explodes into two objects, then the explosion leads to an increased kinetic energy.

If two objects stick together, the collision is completely inelastic.

For inelastic collisions, solve for final velocities using conservation of momentum. For example, if object 1 collides with object 2 and they leave stuck together, then $m_1v_{1\mathrm{i}}+m_2v_{2\mathrm{i}} = (m_1+m_2)v_f$.

Elastic collisions are those in which mechanical energy is conserved. Examples include billiard balls bouncing, a springy ball bouncing, a spacecraft fly-by.

For elastic collisions, solve for final velocities using conservation of momentum and conservation of energy. The conservation of energy statement can be simplified to $v_{app} = v_{sep}$, where $v_{app} = v_{1\mathrm{i}}-v_{2\mathrm{i}}$ and $v_{sep} = v_{2\mathrm{f}}-v_{1\mathrm{f}}$.

In two (or three) dimensions, conservation of momentum applies to each axis. That is, momentum is conserved in $x$ direction, and in $y$ direction, and in $z$ direction.

Center of mass is the mean position of matter in an object or system. For a system with two masses, it is $x_{CM} = (m_1x_1+m_2x_2)/(m_1+m_2)$, in the $x$ direction. More generally, the center of mass is a vector, $\mathbf{x}_{\mathrm{CM}}$.

The center of mass of a projectile exhibits conservation of momentum and travels according to the projectile equations that we studied before (parabolic motion, etc.). This is independent of object rotations or dynamics that are internal to the object (e.g. exploding).