Physics 2311 Mechanics (updated for Giancoli)

Equation list for Exam I

Chapter 1 Measurement and Units

Base mechanical units (SI system): meters, kg, seconds
Dimensions for base units: L, M, T
Dimensions of area: $[A]=L^2$, of volume: $[V]=L^3$
Standard Deviation: sigma = $\sigma=\sqrt{\frac{\sum(x_i-\mu)^2}{N-1}}$

Chapter 2 Motion in 1-D

Definitions

Displacement. $\Delta\vec{x}=\vec{x}_f-\vec{x}_i$
Average velocity. $\vec{v}_{avg}=\frac{\Delta\vec{x}}{\Delta t}$
Average speed. $s_{avg}=\frac{d}{\Delta t}$ (*d* is a path length)
Instantaneous velocity. $\vec{v}_{inst}=\frac{d\vec{x}}{dt}$
Instantaneous speed. $s=|\vec{v}_{inst}|$ (the magnitude of the instantaneous velocity)
Average acceleration. $\vec{a}_{avg}=\frac{\Delta\vec{v}}{\Delta t}$
Instantaneous acceleration. $\vec{a}_{inst}=\frac{d\vec{v}}{dt}$

Equations of motion

Stationary object: $x(t) = x_0$
Constant velocity: $x(t) = x_0 + v_0t$
Constant acceleration: $x(t) = x_0 + v_0t + \frac{1}{2}at^2$

Kinematics Equations for Particle Under Constant Acceleration

Final velocity $v_{xf}=v_{xi}+a_xt$
Average Velocity $v_{x,avg}=\frac{v_{xi}+v_{xf}}{2}$
Position as function of time: $x_f=x_i+v_{x,avg}t$
Position as function of time: $x_f=x_i+v_{xi}t+\frac{1}{2}a_xt^2$

Velocity change related to position change: $v_f^2 - v_i^2 = 2a(x_f - x_i)$

Chapter 3 Vectors

Vector component form: $\vec{A} = A_x\hat{i} + A_y\hat{j}$

Vector sum: $\vec{A} + \vec{B} = (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j}$

Components of a vector given in polar coordinates, (r,θ): x=r cos θ , y=r sin θ.

Polar coordinates of a vector given in rectangular coords. (x,y):

$$r = \sqrt{x^2 + y^2} \quad \text{and} \quad \theta = \tan^{-1}\left(\frac{y}{x}\right)$$

Chapter 3 Motion in Two Dimensions

Definitions ... (Most of these are very similar to the Ch. 2 equations)

Position vector: $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

Displacement: $\Delta\vec{r} = \vec{r}_f - \vec{r}_i$

Average velocity: $\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t}$. Instantaneous velocity: $\vec{v}_{inst} = \frac{d\vec{r}}{dt}$

Average acceleration: $\vec{a}_{avg} = \frac{\Delta\vec{v}}{\Delta t}$. Instantaneous acceleration: $\vec{a}_{inst} = \frac{d\vec{v}}{dt}$

For the special case of uniform acceleration ... (very similar to Ch. 2 kinematic equations)

Final velocity $\vec{v}_f = \vec{v}_i + \vec{a}t$

Average Velocity $\vec{v}_{avg} = \frac{\vec{v}_i + \vec{v}_f}{2}$

Position as function of time: $\vec{r}_f = \vec{r}_i + \vec{v}_{avg}t$

Position as function of time: $\vec{r}_f = \vec{r}_i + \vec{v}_i t + \frac{1}{2}\vec{a}t^2$

Velocity change related to position change: $\vec{v}_f \cdot \vec{v}_f - \vec{v}_i \cdot \vec{v}_i = 2\vec{a} \cdot (\vec{r}_f - \vec{r}_i)$

Projectile Motion ...

Time to reach max height: $t_{max} = \frac{v_i \sin\theta_i}{g}$ (v_i is the magnitude of the initial velocity)

Maximum height: $h_{max} = \frac{v_i^2 \sin^2\theta}{2g}$

Range: $R = \frac{v_i^2 \sin 2\theta}{g}$

Uniform circular motion ...

Centripetal acceleration: $a_c = \frac{v^2}{r}$

Period of circular motion: $T = \frac{2\pi r}{v}$

Non-uniform circular motion ...

Total acceleration: $\vec{a} = \vec{a}_r + \vec{a}_t$ (radial + tangential) where $\vec{a}_r = -a_c \hat{r} = \frac{-v^2}{r} \hat{r}$ and $a_t = d \frac{|\vec{v}|}{dt}$

Relative motion ...

A position of the point P is observed by person A is $\vec{r}_{PA}$. If person B moves with velocity $\vec{v}_{BA}$ as seen by person A. Then $\vec{r}_{PB} = \vec{r}_{PA} - \vec{v}_{BA} t$ gives the position of P as seen by person B. (Assuming that coord systems are coincident at t=0.)

The velocities of point P observed by A and B are then given by: $\vec{v}_{PB} = \vec{v}_{PA} - \vec{v}_{BA}$

The acceleration of point P is the same for A and B: $\vec{a}_{PB} = \vec{a}_{PA}$

Chapter 4 Forces and The Laws of Motion

Newton's 1st: when observed from an inertial frame of reference, an object will maintain a constant velocity unless acted upon by some net force.

Newton's 2nd: $\vec{a} = \frac{\vec{F}_{net}}{m}$

Newton's 3rd: $\vec{F}_{12} = -\vec{F}_{21}$

Gravitational Force (near Earth's surface). $\vec{F}_g = m\vec{g}$

Weight = the force of gravity on a mass, W=mg, measured in Newtons.

Apparent weight = the force of a scale on a suspended mass which may be accelerating.

Gravitational mass = inertial mass

Chapter 5 Friction and Circular Motion

Kinetic Friction $f_k = \mu_k N$

Static Friction $f_s = F_{app}$ if $F_{app} \leq f_{s,max}$ where $f_{s,max} = \mu_s N$

Centripetal acceleration: $a_c = v^2/r$ $\vec{a}_c = \frac{v^2}{r}(-\hat{r})$

Centripetal force: $\vec{F}_c = m\vec{a}_c = m\frac{v^2}{r}(-\hat{r})$

For an object in uniform circular motion, the net force is: $\Sigma \vec{F} = m\vec{a}_c = \vec{F}_c$

For an object in non-uniform circular motion, the net force is: $\Sigma \vec{F} = m\vec{a}_c + m\vec{a}_t = \vec{F}_c + \vec{F}_t$

Tension in a pendulum string (non-uniform circular motion): $T = mg\cos\theta + m\frac{v^2}{r}$