Physics 2311 Mechanics

Equation list for Exam I

Chapter 1 Measurement and Units

Density. $\rho \equiv M/Vol$

Dimensions for base units: L, M, T

Chapter 3 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. $v_{avg} = \frac{s}{\Delta t}$ (*s* is a path length)

Instantaneous velocity. $\vec{v}_{inst} = \frac{d\vec{x}}{dt}$

Instantaneous speed. $v = |\vec{v}_{inst}|$

Average acceleration. $\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$

Instantaneous acceleration. $\vec{a}_{inst} = \frac{d\vec{v}}{dt}$

Equations of Motion for Particle Under Constant Acceleration

Final velocity $v_{xf} = v_{xi} + a_x t$

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: $x_f = x_i + v_{xi} t + \frac{1}{2} a_x t^2$

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

Chapter 2 Vectors

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

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 4 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 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 $a_t=\left|\frac{dv}{dt}\right|$

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.

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

Chapter 5 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). $\vec{F}_g=m\vec{g}$

Kinetic Friction $f_k=\mu_k N$

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

Chapter 6 Circular Motion and Other Applications of Newton's Laws

For an object in uniform circular motion, $\Sigma\vec{F}=m\vec{a}_c=\vec{F}_c$

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

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