Exam 1 Cheatsheet

Kinematics

Variable	Equation
Velocity	$v = at + v_0$
Position	$\Delta x = v_0 t + \frac{1}{2}at^2$
Missing t	$v^2 = 2a\Delta x + v_0^2$
Missing a	$\Delta x = \frac{v+v_0}{2}t$
Missing v_0	$\Delta x = vt - \frac{1}{2}at^2$

General guidelines for solving problems

1. List the known and unknown quantities.
2. Determine the variable we are solving for and what variables are needed to solve it.
3. Derive an equation using those given to solve for your variables.
4. Plugin a numbers and don't forget units.

Vector algebra

- polar → component: $a_x = a\cos\theta$ and $a_y = a\sin\theta$
- component → polar: $a = \sqrt{a_x^2 + a_y^2}$ and $\tan\theta = \frac{a_y}{a_x}$

  - note that finding $\arctan\theta$ may need to check orientation of the resulting vector angle
- dot product gives a scalar that is the magnitude of a vector **B** in the direction of a vector **A**:

$$\mathbf{A}\cdot\mathbf{B} = AB\cos\theta \quad \text{OR} \quad \mathbf{A}\cdot\mathbf{B} = A_xB_x + A_yB_y + \ldots$$

- scalar product gives a vector that is perpendicular to the two vectors:

$$\mathbf{A}\times\mathbf{B} = AB\sin\theta\hat{n}$$

where $\hat{n}$ is a unit vector in a direction perpendicular to **A** and **B**. For component vectors

$$\mathbf{A}\times\mathbf{B} = \det\begin{bmatrix}\hat{i} & \hat{j} & \hat{k}\\ a_x & a_y & a_z\\ b_x & b_y & b_z\end{bmatrix} = \begin{bmatrix}a_y & a_z\\ b_y & b_z\end{bmatrix}\hat{i} + \begin{bmatrix}a_x & a_z\\ b_x & b_z\end{bmatrix}\hat{j} + \begin{bmatrix}a_x & a_y\\ b_x & b_y\end{bmatrix}\hat{k}$$
$$= (a_yb_z - b_ya_z)\,\hat{i} + (a_xb_z - b_xa_z)\,\hat{j} + (a_xb_y - b_xa_y)\,\hat{k}$$

Motion in two dimensions

Variable	Equation
Horizontal displacement	$\Delta x = v_0\cos\theta t$
Vertical displacement	$\Delta y = v_0\sin\theta t - \frac{1}{2}gt^2$
Vertical velocity	$v_y = v_0\sin\theta - gt$
Trajectory	$\Delta y = \tan\theta\Delta x - \frac{g\Delta x^2}{2(v_0\cos\theta)^2}$
Range	$R = \frac{v_0^2\sin 2\theta}{g}$

Guidelines for solving problems

1. Simplify the problem to each dimensional component.
2. Solve each component with the same process as kinematics
3. Horizontal motion is linear and vertical motion is parabolic because acceleration is zero and a constant respectively.
4. Equation for range can only be used when $\Delta y = 0$, otherwise use Trajectory and solve for Δx.

Newton's Laws

1. If $\vec{F}_{\text{net}} = 0$ then $\vec{a} = 0$
2. $\vec{F}_{\text{net}} = m\vec{a}$
3. $\vec{F}_{AB} = -\vec{F}_{BA}$

Annecdotes on applying Newton's Laws

1. $\vec{F}_{\text{net}}$ is comprised of components $F_{\text{net},x} = ma_x$, $F_{\text{net},y} = ma_y$, $\vec{a}$ represents the acceleration of the entire system.
2. Draw free-body diagram for all objects in a system and solve the forces independently.
3. We can obtain equations for the forces acting on an objects and set up a system of equations to eliminate variables.