Summary of critical formulas and important facts

Physics 298 – Test 1

Velocity and Acceleration

- Average velocity $\overline{\boldsymbol{v}} = \frac{\Delta \boldsymbol{r}}{\Delta t} = \frac{\boldsymbol{r_f - r_i}}{\Delta t}$
- Average acceleration $\overline{\boldsymbol{a}} = \frac{\Delta \boldsymbol{v}}{\Delta t} = \frac{\boldsymbol{v_f - v_i}}{\Delta t}$
- In one dimension, instantaneous velocity (**v**) and acceleration (**a**) are the slopes (at a particular point) of the x and v versus t curves, respectively.
  For constant acceleration (velocity) motion, average and instantaneous accelerations (velocities) are equal.

One dimensional motion under constant acceleration

$$v_f = v_i + at$$

$$x = v_i t + {}^1\!/_2\, at^2$$

$$x = {}^1\!/_2 (v_i + v_f) t$$

$$v_f^2 = v_i^2 + 2ax$$

- For constant velocity motion x = vt
- Free fall under the influence of (constant) gravitational acceleration is described by the above equations with a = -g

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Vectors

- Addition and subtraction by resolution into components
- Unit vector notation – **i**, **j**, **k**
- Dot (scalar) product: $\boldsymbol{a} \cdot \boldsymbol{b} = |\boldsymbol{a}||\boldsymbol{b}| cos\theta_{ab}$

- Vector (cross) product: $\boldsymbol{a} \wedge \boldsymbol{b} = \hat{\boldsymbol{u}}|\boldsymbol{a}||\boldsymbol{b}|sin\theta_{ab}$ where the unit vector $\hat{\boldsymbol{u}}$ is at right angles to **a** and **b** whose sense is given by the right-hand rule.

Projectile Motion

- Independent x and y motion.
- Kinematic equations above represent y motion.
- x motion is constant velocity motion, $x = v_{ix}t$
- If projected initial velocity (v_0) is at an angle θ to horizontal then, $v_{ix} = v_0 \cos\theta$ and $v_{iy} = v_0 \sin\theta$

Uniform Circular Motion

- Centripetal acceleration is given by, $a = v^2/R$, directed towards the centre of the circle

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Relative Velocity

$$\boldsymbol{V'} = \boldsymbol{V} + \boldsymbol{V_R}$$

Newton's Laws of motion

- 2nd Law: $\mathbf{F_{net}} = m\mathbf{a}$ ($F_x = ma_x$, $F_y = ma_y$, $F_z = ma_z$)

- 1st Law: Special case of the second law when acceleration is zero. For objects at rest or in constant velocity motion there is no ***net*** force.

- 3rd Law: For every "action" force there is an equal but opposite "reaction" force. Note that the action/reaction force pairs act on different objects.

Force Laws

- Weight:

$$w = \text{mg}$$

The weight of an object is equal to the gravitational force acting on the object. Its direction is always towards the centre of the earth.

- Friction:
  - Static friction

$$F_{fs} \leq \mu_s \mathrm{N}$$

  - Kinetic friction

$$F_{fk} = \mu_k \mathrm{N}$$

- Force of friction opposes attempted or actual relative motion of two objects

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Application of Newton's laws via *free-body* diagrams.

Centripetal Force

$$F_c = \frac{mv^2}{R}$$

- Direction is always towards the centre of the circle
