Summary of critical formulas and important facts

Physics 298 – Test 2

Work and Power

- Constant Force:

$$W = \vec{F} \bullet \vec{d}$$

- Variable 1D force:

$$W = \int_{x_1}^{x_2} F(x)dx \;=\; \text{Area under F(x) between } x_1 \text{ and } x_2$$

- Power:

Instantaneous Power = dW/dt

Average Power = W_{tot}/t

$$P = \vec{F} \bullet \vec{v} \;\; \text{(constant } \mathbf{F}\text{)}$$

Hooke's Law : Stretched/Compresed Spring

- Restoring Force:

$$F_R = -kx$$

- Work:

$$W = \tfrac{1}{2} kx^2$$

Energy

- Kinetic Energy:

$$KE = \tfrac{1}{2} mv^2$$

- Potential Energy:
  - Gravitational

$$U_g = mgh$$

  - Elastic

$$U_e = \tfrac{1}{2} kx^2$$

Work Energy and Conservation of Energy

- Work energy theorem:

$$W = \Delta K = K_f - K_i$$

- Conservation of energy:

$$\Delta U + \Delta K = W_{NC}$$

- For conservative forces only, $\Delta U + \Delta K = 0$, or U + K, the mechanical energy is constant

- The position of $U_g = 0$ is arbitrary

Centre of Mass

$$\vec{r}_{cm} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i}$$

Momentum and Collisions

- Momentum

$$\vec{p} = m\vec{v}$$

- 2nd Law, alternate form

$$\vec{F} = \frac{d\vec{p}}{dt}$$

- Impulse

$$\vec{I} = \vec{F}\ \Delta t = \Delta\vec{p}$$

- With no external force on a system, momentum is conserved (independently in xyz)

$$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = 0$$

- Elastic collisions : KE conserved

- Inelastic collision: KE not conserved. In a completely inelastic collision the colliding object stick together.

Rotational kinematic equations

$$\omega_f = \omega_i + \alpha t$$
$$\theta = \tfrac{1}{2}(\omega_i + \omega_f)t$$
$$\theta = \omega_i t + \tfrac{1}{2}\alpha t^2$$
$$\omega_f^2 = \omega_i^2 + 2\alpha\theta$$

Rotational – Translational a and v

$$v = \omega R$$
$$a_T = \alpha R$$

- Centripetal acceleration

$$a_C = a_{Rad} = \frac{v^2}{R} = \omega^2 R$$

Rotational Dynamics

- Torque:

$$\underline{\tau} = \underline{r} \times \underline{F}$$
$$|\underline{\tau}| = |\underline{r}||\underline{F}|\sin\theta_{rF} = |\underline{r}|F_\perp = |\underline{F}|r_\perp$$

- Angular momentum:

$$\underline{\ell} = \underline{r} \times \underline{p}$$
$$|\underline{\ell}| = |\underline{r}||\underline{p}|\sin\theta_{rp} = |\underline{r}|p_\perp = |\underline{p}|r_\perp$$

- Moment of inertia:

$$I = \sum_i m_i r_i^2$$

- Parallel axis theorem:

$$I_P = I_C + Mh^2$$

- Kinetic energy:

$$K = \tfrac{1}{2} I\omega^2$$

- Angular momentum:

$$L = I\omega$$

- Power:

$$Power = \tau\omega$$

- Work:

$$W = \int \tau \, d\theta = \tau \, \Delta\theta$$

- 2nd Law:

$$\tau = I\alpha = \frac{dL}{dt}$$

- Angular momentum conservation:

$$L_i = L_f$$

$$I_i\omega_i = I_f\omega_f$$

Remember, $I_i \neq I_f$ in many cases