**Oscar Han Physics Unit 3 Cheat Sheet: Motion**

**Inclined planes:**
- Weight force ($F_w$): acts from centre of mass
- Normal force ($F_N$) = $mg \cos \theta$: acts perpendicularly from surface
- Friction (ignore if necessary)
- Is a RESULTANT force
- $v^2 = u^2 + 2ax$ \( a = \frac{\Delta v}{\Delta t} \)

**Graphs:**
- Displacement-time
- Velocity-time
- Acceleration-time

**Newton’s laws:**
1. Every object continues to be at rest, or continues with constant velocity, unless it experiences an unbalanced force (law of inertia)
2. $\sum F = ma$
3. For every action there is an equal and opposite reaction. Action-reaction pairs act on different objects; forces of action-reaction pairs can’t be added together

**Theory:**
- An object will experience apparent weightlessness when falling with an acceleration equal to the gravitational field strength (free fall towards earth)
  - FEEL WEIGHTLESS
  - $F_N$, which gives experience of our own weight, is equal to 0
  - Gravitational weight force is force by earth on you
  - Reaction forces is force by surface on you
  - $mg - N = ma$
  - True weightlessness when $g = 0$ $N$ $kg^{-1}$

**Standing on ground isn’t action-reaction because the forces act on the same object, and aren’t always equal and opposite (if on incline)**

**Projectile motion:**
- Only force acting on projectile is $F_g$
- Air resistance acts in opposite direction of motion

**Impulse (change in momentum):**
- In the same scenario, impulse remains constant. Since impulse is given by $\sum F \Delta t$, an increase in time results in a smaller average force felt
- $F \Delta t = m \Delta v$
- In an isolated system, $\sum F_{external} = 0$

**Work, energy (J), power (W):**
- $W = Fx \cos \theta$
- $U_g = mg \Delta h$
- In an elastic collision, $E_{k\text{ initial}} = E_{k\text{ final}}$
- During an elastic collision, some kinetic energy is changed into elastic potential energy and back into kinetic energy
- In an inelastic collision, kinetic energy transformed into other forms of energy; sound, heat (energy involved in deforming objects)
- $Power = Force \times velocity$
- $mg \Delta h = \frac{1}{2} kx^2$

**Banked corners:**
- $F_N > F_W$ ($F_W$ is hypotenuse when resolving forces)
- Only gravitational weight force and normal force
- DON’T LABEL CENTRIPETAL FORCE
- No sideways frictional force when travelling at design speed
- $design speed, v = \sqrt{gr \tan \theta}$

**Horizontal circular motion:**
- $\sum F = ma = \frac{mv^2}{R} = \frac{4\pi^2 R m}{R^2}$
- $a_{centripetal} = \frac{v^2}{R} = \frac{4\pi^2 R}{R^2}$
- Labeling forces:
  - Tension, $F_t$ if there is string
  - $F_g$, weight force
- $v = \sqrt{gr}$

**Satellites:**
- MUST CONVERT km to m
- Geostationary: period matches central body rotation period

**Units:**
- $n$ nano $10^{-9}$
- $\mu$ micro $10^{-6}$
- $m$ milli $10^{-3}$
- $c$ centi $10^{-2}$
- $k$ kilo $10^3$
- $M$ mega $10^6$
- $G$ giga $10^9$
- $t$ tonne $10^3$ kg

- **Tension** = force required to pull trailer ($ma + \text{resistance}$)
  - MUST CONSIDER ACCELERATION DOWN INCLINED PLANE DUE TO GRAVITY

**Vertical circular motion:**
- $\sum F = F_W + F_N$
- ASSIGN +ve and -ve

**Theory:**
- An object will experience apparent weightlessness when falling with an acceleration equal to the gravitational field strength (free fall towards earth)
  - FEEL WEIGHTLESS
  - $F_N$, which gives experience of our own weight, is equal to 0
  - Gravitational weight force is force by earth on you
  - Reaction forces is force by surface on you
  - $mg - N = ma$
  - True weightlessness when $g = 0$ $N$ $kg^{-1}$

- Banking reduces/eliminates the need for sideways frictional forces and allows cars to travel faster without skidding out of the circular path; centripetal force (component of $F_N$) is increased
- In circular orbit, no work is done as $E_k$ and $U_g$ remain constant
- An isolated system is where the collision involves only internal forces (gravity and friction are outside forces)
- Momentum is always conserved before, after and during a collision
**Physics Unit 3 Cheat Sheet: Electronics & photonics/Structures & materials**

### Formulae:
- \( I = \frac{Q}{t} \)
- \( P = \frac{E}{t} = VI = I^2R = \frac{V^2}{R} \)
- \( A_V = \frac{\Delta V_{out}}{\Delta V_{in}} \)
- **Ammeter in series**
- **Voltmeter in parallel**

### Diodes:
- Control current and voltage
- Converts AC to DC (rectification)
- Voltage controlled switch
- Maintains constant voltage across itself (controls voltage)

### Theory (voltage amplification):
- **Biasing** is where the amplifier is operated so that the input voltage varies about the middle of the linear region to maximise the range of distortion-free amplification
- **Bias voltage** is the offset voltage added to the varying input signal so that \( V_{in} \) is in the middle of the linear amplification region
- **Clipping** is a form of amplifier distortion; it occurs when the input signal is outside the amplifier’s input limits (cut-off/saturation mode)
  - Saturation: max. \( V_{in} \)
  - Cut-off: min. \( V_{in} \)

### Theory:
- **Attenuation** is the loss of power between two points as a signal travels through a medium; electrical/ optical power lost
  - Skin effect: attenuation increases with increasing frequency in copper wires
- **Bandwidth** is the range of frequencies which can pass through a certain medium with limited attenuation
- **Transducers** convert electrical energy to non-electrical energy or vice versa
  - Optical to electrical
  - Electrical to optical
  - Optical detectors convert light energy to electrical energy
- **Modulation**:
  - changing the intensity of the carrier wave to replicate the amplitude variation of the information signal so that the signal may propagate more efficiently
  - Input signal varies with light/ electromagnetic radiation intensity
  - Light intensity modulation is where the amplitude (hence light intensity) of the carrier can be made to replicate the amplitude variation of the information signal
  - Amplitude modulation is changing the amplitude of the carrier wave by superimposing the waveform of the input signal
  - Demodulation:
    - Separation of the information signal from the carrier wave
    - Varying light creates an electrical signal
- An analogue signal’s brightness/intensity varies through a range of values in carrying the information

### Structures and materials:
- \( \sigma = \frac{F}{A}, \epsilon = \frac{\Delta L}{L}, Y = \frac{\sigma}{\epsilon} \)
- **Compression**: pushed/squeezed
- **Tension**: pulled
- **Shear**: two forces acting in opposite directions
- **Bending**: compression and tension
- **Strength**: maximum stress before failure
- **Elastic behaviour**: material returns to original dimensions after undergoing stress
- **Elastic limit**: maximum stress that a material can undergo before deforming permanently
- **Plastic deformation**: material is permanently deformed
- **Tough**:
  - Amount of strain energy material can store before failure
  - Area under stress-strain graph gives **strain energy (per unit volume)**
- **Brittle**: little/no plastic region
- **Ductile**: significant plastic region
- **Stiff**:
  - Resistance to deformation
  - Young’s modulus
  - Gradient of stress-strain graph

### Rotational equilibrium:
- net torque is zero, no turning occurs

### Translational equilibrium:
- acceleration is zero

### Centre of Mass:
- \( X_{Centre of Mass} = \frac{m_Ax_A + m_Bx_B + m_Cx_C}{m_A + m_B + m_C} \)

### Torque:
- \( \tau = rF \sin \theta \)