

# Physics Unit 3 Cheat Sheet (Motion and Gravity)

## Energy (J) and Force (N)

$$E_k = \frac{1}{2}mv^2$$

$$U_g = mgh$$

(only if gravity is constant!)

$$W = Fx \cos \theta$$

$$U_s = \frac{1}{2}kx^2$$

$$F = kx$$

$$F = ma \sin \theta$$

**AVOID**

## Power (W)

$$P = VI$$

$$P = \frac{E}{t}$$

$$P = Fv$$



(normal force acts at right angles to the surface)

## Momentum ( $\text{kg m s}^{-1}$ ) and Impulse ( $\text{N s}$ )

$$p = mv$$

$$m_1(v_1 - u_1) = m_2(v_2 - u_2)$$

$$\text{Impulse} = \Delta p = \Sigma F \Delta t = m \Delta v$$

### SI Units

Speed:  $\text{ms}^{-1}$

Acceleration:  $\text{ms}^{-2}$

Distance: m

Time: s

Mass: kg

Force: N

Energy: J

Power: W

Current: A

Resistance:  $\Omega$

Voltage: V

note that impulse does not depend on acceleration, i.e. a collision will have the same impulse regardless of the presence of padding

Sources of centripetal force:

- Tension, eg:
  - Gravity
  - Along a string
- Sideways frictional forces

## Motion ( $\text{m}$ , $\text{m s}^{-1}$ , $\text{m s}^{-2}$ )

$$v = u + at$$

$$x = \frac{t(u + v)}{2}$$

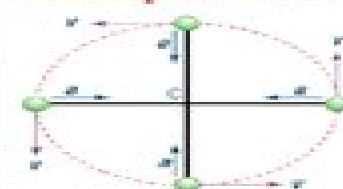
$$x = ut + \frac{1}{2}at^2$$

$$x = vt - \frac{1}{2}at^2$$

$$v^2 = u^2 + 2ax$$

$$V_{B \rightarrow A} = V_B - V_A$$

## Centripetal Motion



$$\Sigma F = ma = \frac{mv^2}{r} = \frac{4\pi^2 m r}{T^2}$$

$$a_{\text{centripetal}} = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2}$$

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{T^2}{2\pi r}$$

## Inclined Planes



$$\Sigma F = F_g \sin \theta$$

$$a = g \sin \theta$$

## Newton's Laws

1. Every object continues in a state of rest or constant velocity unless acted on by an unbalanced force.
  2. The rate of change of momentum is directly proportional to the magnitude of the net force and is in the direction of the net force.
  3. For every action there is an equal and opposite reaction. Action-reaction forces act on **different** objects, e.g. Joe and wall!
- Newton's laws assume that space and time are absolute, in contrast with Einstein, who proposed that space and time are relative.
- The inertial frame of reference refers to objects moving at a constant speed, where Newton's laws work (i.e. the third law wouldn't work if Joe broke the wall down).

Driving force = weight force - normal force

## Normal Force



|       |       |                   |
|-------|-------|-------------------|
| p     | pico  | $10^{-12}$        |
| 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 | $10^3 \text{ kg}$ |



## Graph interpretation

| Graphs    | Y-axis     | Area under                    | Gradient    |
|-----------|------------|-------------------------------|-------------|
| Extension | Force      | $U_s$                         | Spr. const. |
| Time      | Velocity   | Displ.                        | Accel.      |
| Time      | Accel.     | Velocity                      | -           |
| Time      | $\Sigma F$ | Impulse                       | -           |
| Displ.    | Force      | Work                          | -           |
| Dist      | $F_g$      | Work                          | -           |
| Strain    | Stress     | $E_{\text{ext}} / \text{m}^2$ | YM (E)      |

## Collisions

Elastic:

- Energy conserved
- Momentum conserved

Inelastic:

- Energy lost as heat / sound / deformation
- Momentum conserved

$$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$$

Acceleration is independent of mass

Force acts equally on both bodies

Velocity is directed at a tangent to the path

## Gravity

|     |                                                     |
|-----|-----------------------------------------------------|
| $g$ | gravitational field strength ( $\text{N Kg}^{-1}$ ) |
| $a$ | acceleration ( $\text{M s}^{-2}$ )                  |
| $F$ | Force (N)                                           |
| $v$ | velocity ( $\text{M s}^{-1}$ )                      |
| $M$ | Central mass (kg)                                   |
| $m$ | Orbiting mass (kg)                                  |
| $r$ | radius or orbit (m)                                 |
| $T$ | period of orbit (s)                                 |

$$a = g = \frac{GM}{r^2} = \frac{4\pi^2 r}{T^2} = \frac{v^2}{r}$$

$$F = \frac{GMm}{r^2} = \frac{4\pi^2 mr}{T^2} = \frac{mv^2}{r}$$

$$v = \frac{2\pi r}{T} = \sqrt{\frac{GM}{r}}$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$v_1 \sqrt{R_1} = v_2 \sqrt{R_2}$$

Action / Reaction

- Action/reaction forces:
- Always exist in pairs
- Are equal in magnitude
- Act in opposite directions
- Act on separate objects

This value is a constant for bodies orbiting the same central mass

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