Essential Notes on Mechanics

For the new A level syllabus

Common Modelling Assumptions

Ignore air resistance
Force of gravity acts constantly

Inextensible	$\Rightarrow$	no stretching
Thin	$\Rightarrow$	no diameter or thickness
Light	$\Rightarrow$	no mass
Rigid	$\Rightarrow$	no bending
Smooth	$\Rightarrow$	no friction
Particle	$\Rightarrow$	no size

Newtons Laws of Motion

1. Every particle continues in a state of uniform motion unless acted upon by an external force.
2. The net force is equal to the rate of change of momentum. $F = ma$
3. Every action has an equal and opposite reaction

Suvat

$v = u + at$	(no s)
$s = ut + \frac{1}{2}at^2$	(no u)
$s = vt - \frac{1}{2}at^2$	(no v)
$s = \frac{1}{2}(u + v)t$	(no a)
$v^2 = u^2 + 2as$	(no t)

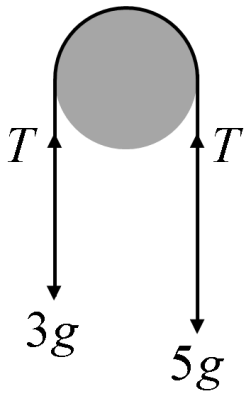
Equilibrium

Result force equals zero

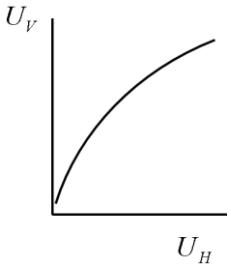
Friction

$F = \mu R$ where $0 < \mu < 1$

Pulleys and Tension



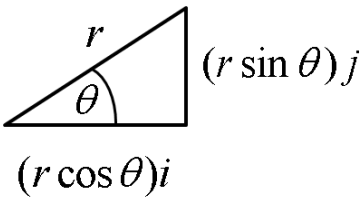
Projectiles



U_H acts constantly U_V subject to g ms^{-2}

Care required with stating which is positive vertical direction.

Vectors



$r = ai + bj$ $\quad |r| = \sqrt{a^2 + b^2}$ $\quad \tan\theta = \frac{b}{a}$

Calculus in Kinematics

↓ Differentiate ↓				↑ Integrate ↑
	Displacement	x	x	
	Velocity	$v = \frac{dx}{dt}$	$v = \dot{x}$	
	Acceleration	$a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$	$a = \dot{v} = \ddot{x}$	

Note that when $t = 0$, $displacement = 0$.
When integrating, use initial/boundary conditions to find the c value.

$$r = x\boldsymbol{i} + y\boldsymbol{j} + z\boldsymbol{k} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

$$v = \frac{dx}{dt}\boldsymbol{i} + \frac{dy}{dt}\boldsymbol{j} + \frac{dz}{dt}\boldsymbol{k}$$

$$a = \frac{d^2x}{dt^2}\boldsymbol{i} + \frac{d^2y}{dt^2}\boldsymbol{j} + \frac{d^2z}{dt^2}\boldsymbol{k}$$

$$|v| = \sqrt{\dot{x}^2 + \dot{y}^2 + \dot{z}^2}$$

Moments (turning forces, torque, Nm)

Anticlockwise = +ve Clockwise = -ve

$$Moment = \ perpendicular\ distance \times force = \ |F| \cdot d$$

Forces through the pivot exert no moment/torque.

Most problems involve finding resultant (translational) force and resultant moment around one or more points, then using these to determine unknown forces or distances. It is possible to use resultant force and resultant moment to calculate position of resultant moment.

Equilibrium $\Rightarrow$

resultant moment = 0 (no turning effect) **and** resultant force = 0 (no translational effect)