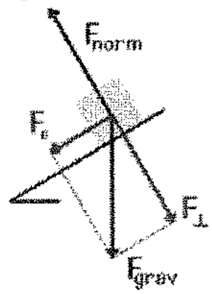
SKILL 22 – Horizontal, Vertical and Inclined Plane Scenarios

Several equations listed in the descriptions below will be covered in more detail in Topic 3B (Other Force Equations)

Term	Variable	What you need to understand and apply…
WEIGHT	F_g	The force due to the gravitational field is known as weight $\mathbf{F_g = mg}$ or $F_g = G\frac{m_1 m_2}{r^2}$ [TOPIC 3B/Skill 6] -For objects on the surface of the Earth weight is always downward. -For two masses attracted at a distance by gravity, weight is always attractive. Weight is the only force for an object in free fall and therefore $\mathbf{F_g = F_{net}}$ for any projectile.
NORMAL FORCE	F_N	The normal force is the force due to the surface that acts perpendicular to an object in response to weight.  Normal forces are always directed perpendicular to the surface. -For equilibrium on level surface with no other vertical force $F_N = F_g = mg$ -For equilibrium on an incline $F_N = F_{g\perp}$ -For vertical acceleration (elevators) F_N is the apparent weight of the object and $F_{net} = F_g + F_N$ -If F_{net} and a are positive (acceleration upward) $F_N > F_g$ -If F_{net} and a are negative (acceleration downward) $F_N < F_g$ -If F_{net} and a are 0 (constant speed or rest) $F_N = F_g$
APPLIED FORCE	F_A	The name for any force that comes from one of the many sources such as person or machine that is not already identified in this list. Saying F_A avoids a lot of awkward Force diagrams
HORIZONTAL FORCE COMPONENT	F_{AX}	The part of an applied force that aligns with the horizontal axis. $\mathbf{F_{AX} = F_A \cos\Theta}$
VERTICAL FORCE	F_{AY}	The part of an applied force that aligns with the vertical axis $\mathbf{F_{AY} = F_A \sin\Theta}$
Frictional Force	F_f	The force between an object and the surface. Always resists or opposes motion. For objects on a level surface $\mathbf{F_{net} = F_{AX} + F_f}$ which means -for equilibrium $\mathbf{-F_f = F_{AX}}$ -for acceleration $\mathbf{F_f = F_{net} + F_{AX}}$ Frictional force also depends on the types of surfaces that are interacting and whether the force is required to start an object in motion (static friction) or to keep an object in motion (kinetic friction). $F_f = \mu F_N$ [TOPIC 3B/Skill 4]
Tension Force	F_T	Force due to a rope or wire etc., that supports or lifts and object. A form of F_A with a specific name.

Parallel Component of Weight (Inclined Plane)	$F_{g\parallel}$	When an object is on an incline the axes are redefined as parallel and perpendicular instead of horizontal and vertical. The weight vector is straight down which is on the vertical axis and weight must be broken into components that align with parallel and perpendicular known $F_{g\parallel}=F_g\sin\Theta$ $F_{g\perp}=F_g\cos\Theta=F_N$  **For Objects on Inclines (with no friction)** $F_\perp = F_{norm}$ $F_\parallel$ **is the net force**
Perpendicular Component of Weight (Inclined Plane)	$F_{g\perp}$	

	LINKING F_{net} EQUATIONS FOR OBJECTS ON A SURFACE		
	Horizontal Axis	**Vertical Axis**	**Inclined Plane**
SCENARIO	**Level Surface** Vertical axis is in equilibrium	**Elevator**	**Ramp** Perpendicular axis is in equilibrium
Frictionless	$F_{net}=ma$ $F_{net}=F_A$ So $F_{net}=F_A=ma$		$F_{net}=F_{g\parallel}=F_g\sin\Theta=mg\sin\Theta$
Equilibrium	$F_{net}=0$ $F_{net}=F_A+F_f$ so $0=F_A+F_f$ $F_A=-F_f$	$F_{net}=0$ $F_{net}=F_N+F_g$ so $0=F_N+F_g$ $F_g=mg$ So $0=F_N+mg$ [mg is negative] So $F_N=F_g=mg$	$F_{net}=0$ $F_{net}=F_{g\parallel}+F_f$ So $0=F_{g\parallel}+F_f$ So $0=mg\sin\Theta+F_f$ [mg is negative] So $F_f=mg\sin\Theta$
Acceleration With more than one force on axis	$F_{net}=ma$ $F_{net}=F_A+F_f$ so $ma=F_A+F_f$ -if acc is positive $F_A>F_f$ -if acc is negative $F_A<F_f$	$F_{net}=ma$ $F_{net}=F_N+F_g$ so $ma=F_N+F_g$ $F_g=mg$ So $ma=F_N+mg$ [mg is negative] -if acc is positive $F_N>F_g$ -if acc is negative $F_N<F_g$ F_N is the apparent weight, F_g does not change regardless of direction of Net Force or Acceleration	$F_{net}=ma$ $F_{net}=F_{g\parallel}+F_f$ So $ma=F_{g\parallel}+F_f$ So $ma=mg\sin\Theta+F_f$ [mg is negative] -if acc is positive $F_{g\parallel}>F_f$ -if acc is negative $F_{g\parallel}<F_f$