## Chapter Five

# The Lows of Motions

## Objects Experiencing A Net Force:

$\Sigma F x = m\, a_x = T$ or $a_x = T/m$

The acceleration occures in the **y** direction

$\Sigma f_y = m\, a_y$ with $a_y = 0 \Longrightarrow \Sigma f_y = 0$

$n + (-F_g) = 0 \Longrightarrow n = F_g$

For constant acceleration $V_{xf} = V_{xi} + a_x t \Longrightarrow V_{xf} = V_{xi} + (T/m)\, t$

And $x_f = x_i + V_{xi} t + (1/2).(T/m).t^2$

Note: **n** = the normal force is not always equal to the magnitude of ($F_g$)

For example suppose a book is lying on a table and you push down on the book with a force **F**, the book is at rest and therefore not accelerating $n - F_g - F = 0$ or $n = F_g + F$ Note : ($n > F_g$)

## Force of Friction:

When an object is in motion either on a surface or in a viscous medium such as air or water, there is resistance to the motion because the object interacts with its surroundings. This resistance called (force of fraction).

Consider you try to drag a trash can filled with yard clippings across the surface of your concrete patio **figure (a)** below its a real surface not an idealized (friction less surface), If we apply an external horizontal force (**F**) to the trash can acting to the right:

1- the trash can be remain stationary if (**F**) is small. The force that counteracts force (**F**) and keep the trash can from moving acts to the left and is called the force of friction ($f_s$), as long as the trash can is not moving ($f_s = F$).

Note: If (**F**) increased, $f_s$ also increases.

2- If we increase the magnitude of (**F**) as in **figure (b)**, the trash can eventually slips when ($f_s$) reaches its max value ($f_{s\ max}$), as in **figure c**.

3- The trash can moves if ($F > f_{s\ max}$), when the trash is in motion, the friction force is called (*force of kinetic friction* $f_k$). The net force ($F-f_k$) is in the x-direction and produces acceleration to the right.

4- If $F= f_s$, the acceleration is zero and the trash can moves to the right with constant speed.

5- If the force is removed, the friction force acting to the left, provids an acceleration of the trash in the x-direction and eventually brings it to rest.

## Experimental Observations:

1- The magnitude of the force of static friction between any two surfaces in contact can have the values: ($f_s < \mu_s.n$) where

$\mu_s$= coefficient of friction (dimentionles constant)

**n**= the normal force exerted by one surface on the other

When the surfaces are on the average of slipping, $f_s = f_{max} = \mu_s.n$, (impending motion).

2- The magnitude of the kinetic friction force acting between two surfaces is: $f_k = \mu_k.n$

$\mu_k$ = coifficient of kinetic friction, it is vary with speed.

3- The values of $\mu_s$ and $m_k$ are depend on the nature of the surfaces, but generally: ($\mu_k < \mu_s$).

4- The direction of of the friction force on an object is parallel to the surface with which the object is in contact and opposite to the actual motion (kinetic friction), or the impending motion (static friction) of the object relative to the surface.

5- The coefficient of friction is independent of the area of contact between the surfaces.

6- The equations (**$f_s \leq \mu_s.n$**) and (**$f_k \leq \mu_k.n$**) are not vector equations, they are relationships between the magnitude of the friction and normal forces. Because the friction and normal forces are perpendicular to each other, the vectores can not be ralated by a multiplicative constant.

**Example 1**: A hocky puck having a mass of (0.3 kg) slides on the horizontal frictionless surface of an ice rink. Two hocky sticks strike the puck similtaneously, exerting the forces on the puck as shown in Figure below. Determine both the magnitude and direction of the puck's acceleration?

$\Sigma F_x = f_{x1} + f_{x2} = f_1 \cos(-20°) + f_2 \cos(60)$
(5.0 N)(0.940) + (8.0 N)(0.5) = 8.7 N
$\Sigma F_y = f_{y1} + f_{y2} = f_1 \sin(-20°) + f_2 \sin(60)$
(5.0 N)(- 0.342) + (8.0 N)(0.866) = 5.2 N
$a_x = (\Sigma f_x) / (m)$ = 8.7 N / 0.3 kg = 29 m/s$^2$
$a_y = (\Sigma fy)/(m)$ = 5.2 N /0.3 kg = 17 m/s$^2$
$a = \sqrt{a^2_X + a^2_y} = \sqrt{(29^2) + (17^2)}$ = 34 m/s$^2$
$\theta = \tan^{-1}(a_y/a_x) = \tan^{-1}(17/29) = 30°$

***Example 2***: A traffic light weight (122 N) hangs from a cable tied to two other cables fastened to a support as in Figure-6. The upper cables are not as strong as the vertical cable and will break if the tension in them exceeds (100 N). Will the traffic light remains hanging in this situation, or will one of the cables break?

***Example 3***: A ball of mass ($m_1$) and a block of mass ($m_2$) are attached by a light weight cord that passes over a frictionless pully negligible mass (Figure-7). Find the magnitude of the acceleration of the two objects and the tension in the cord?