TAM 212

$F = ma$

$\vec{F} = m\vec{a}$

Newton's Law's of Motion – basis for classical mechanics

(1) If there is no net force on an object, then it's velocity is a constant.

Either (1) object is at rest $\vec{v} = 0$

(2) it's moving with constant <u>speed & direction</u>

(2) The acceleration of a body is parallel and proportional to the net force $\vec{F}_{net}$ acting on it, and inversely proportional to the bodies mass m.

$$\boxed{\vec{F}_{net} = m\vec{a} = m\frac{d\vec{v}}{dt}}$$

alternative expression (equivalent)

$\vec{p}$ = momentum = $m\vec{v}$

$$\boxed{\vec{F}_{net} = \dot{\vec{p}}}$$

When no net forces act on an object, momentum is conserved.

TRUE (A)

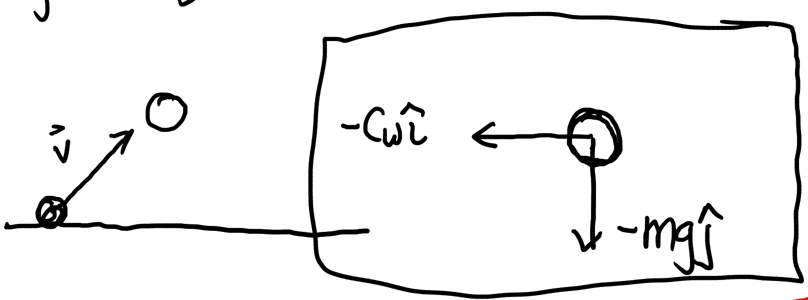
FALSE (B)

(3) When a first body exerts a force $\vec{F}_1$ on a second body, the second body simultaneously exerts a force $\vec{F}_2 = -\vec{F}_1$ on the first body.

Examples 1: Know $\vec{F}$, compute $\vec{a}$

"Method of Assumed Forces"

A cannonball of mass m is fired from the origin, with initial velocity $\vec{V}_o = V_{ox}\,\hat{\imath} + V_{oy}\,\hat{\jmath}$. It experiences a force $\vec{F}_g = -mg\,\hat{\jmath}$ and a wind force $\vec{F}_w = -C_w\,\hat{\imath}$. Find $\vec{a}(t), \vec{v}(t), \vec{r}(t)$



① $m\vec{a} = \vec{F}_{net} = \vec{F}_w + \vec{F}_g$ $\boxed{\vec{a}(t) = \frac{1}{m}\left(-C_w\,\hat{\imath} - mg\,\hat{\jmath}\right)}$

$a_x(t) = -\frac{C_w}{m}$ $a_y = -g$

② $\vec{v}(t) = \vec{V}_o + \int_0^t \vec{a}(\tau)\,d\tau$

$= \vec{V}_o + \int_0^t \left(-\frac{C_w}{m}\,\hat{\imath} - g\,\hat{\jmath}\right)d\tau$

$\vec{v}(t) = \vec{V}_o - \frac{C_w}{m}t\,\hat{\imath} - gt\,\hat{\jmath}$

③ $\vec{r}(t) = \cancel{\vec{r}_0}^{\,0} + \int_0^t \vec{v}(\tau)\,d\tau$

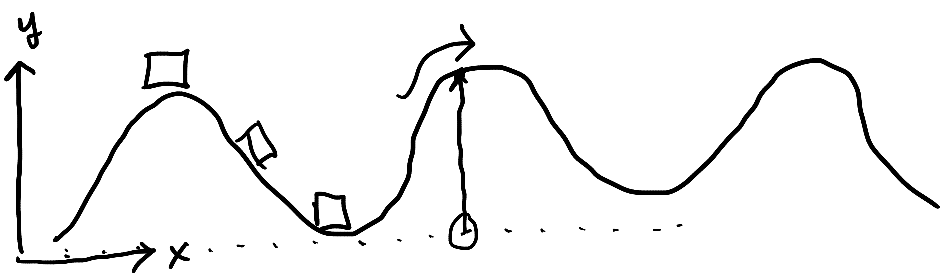
$$= \int_0^t \left[\vec{v}_0 - \frac{c_w}{m}\tau\,\hat{i} - g\tau\,\hat{j} \right] d\tau$$

$$\boxed{\vec{r}(t) = \vec{v}_0 t - \frac{1}{2}\frac{c_w}{m}t^2\,\hat{i} - \frac{1}{2}g t^2\,\hat{j}}$$

Example 2 | Know $\vec{a}$, compute $\vec{F}$

"Method of Assumed Motion"

A car of mass m drives on a sinusoidal road at a constant horizontal speed v_0. The road surface is given by $y = A\sin(kx)$. What is the force of the road on the car?



$$\vec{r}(t) = x(t)\hat{i} + y(t)\hat{j}$$

$$x(t) = v_0 t$$

$$y(t) = A\sin(kx(t)) = A\sin(kv_0 t)$$

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = v_0\hat{i} + Akv_0\cos(kv_0 t)\hat{j}$$

$$\vec{a}(t) = -A(kv_0)^2\sin(kx(t))\hat{j}$$

$$\vec{F} = m\vec{a}$$