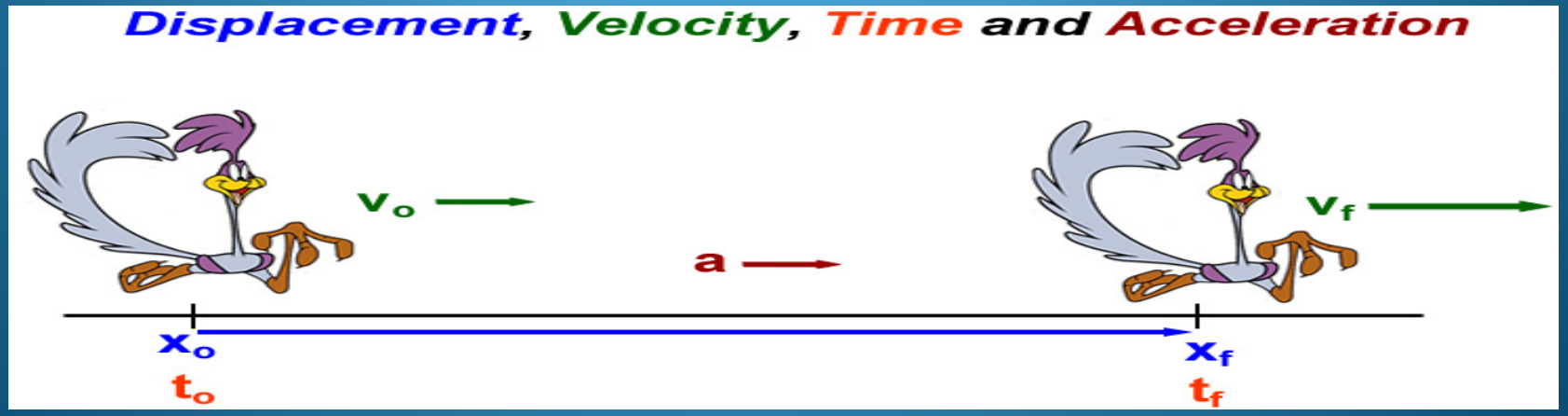
Chapter two
Motion kinematics



Motion kinematics

One –Dimensional Motion

Free Fall Acceleration

Lecture third

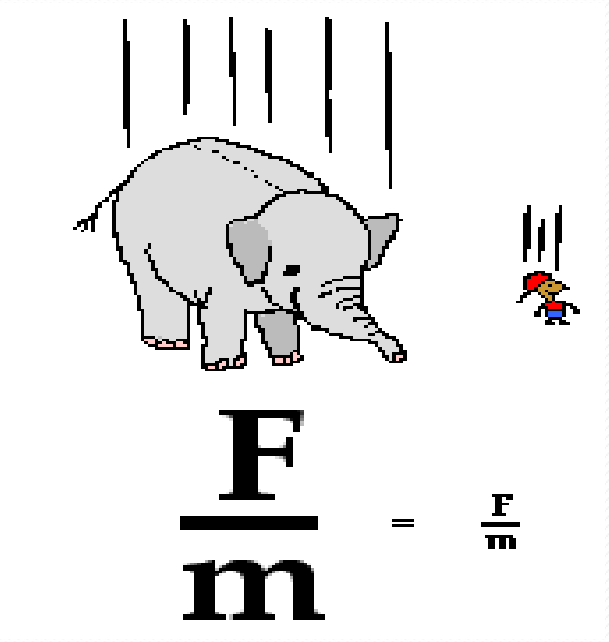
Motion kinematics

- Position vector and displacement vector
- Average velocity and Instantaneous velocity
- The Average and Instantaneous Acceleration
- One -dimensional
- Free fall
- Motion in two dimensions
- Projectile motion

Falling Objects

Near the surface of the Earth, all objects experience approximately the same acceleration due to gravity.

In the absence of air resistance, all objects fall with the same acceleration ,although this may be hard to tell by testing in an environment where there is air resistance



- Earth gravity provides a constant acceleration. Most important case of constant acceleration.
- Free-fall acceleration is independent of mass.
- Magnitude: $|a| = g = 9.8\ m/s^2$
- Direction: always downward, so a_g is negative if define "up" as positive,
- $a = -g = -9.8\ m/s^2$

Free fall kinematics Equations

بما ان تعجيل الجاذبية الارضية ثابت نسبيا على ارتفاعات محدودة من سطح الارض واتجاهها باتجاه مركز الارض ,وبالتالي يمكن استخدام المعادلات الاربعة السابقة مع تغير الرمز x بالرمز y وكدلك التعويض عن التعجيل a بتعجيل الجاذبية الارضية بإشارة سالبة g−ودالك لان تعجيل الجاذبية الارضة دائما في اتجاه مركز الارض وهدا يعبر عنة من خلال المحور y السالب.

عندما يكون اتجاه السرعة الى الاعلى تأخذ اشارة موجبة وادا كان اتجاه السرعة الى الاسفل تأخذ اشارة سالبة

$V=v_0+at$

$V=v_0-gt$

$X=x_0+\frac{1}{2}(v+v_0)t$ → $y=y_0+\frac{1}{2}(v+v_0)t$

$X=x_0+v_0t+\frac{1}{2}at^2$ → $y=y_0+v_0t-\frac{1}{2}gt^2$

$v^2=v_0^2+2a(x-x_0)$ → $v^2=v_0^2-2g(y-y_0)$

Example(1)

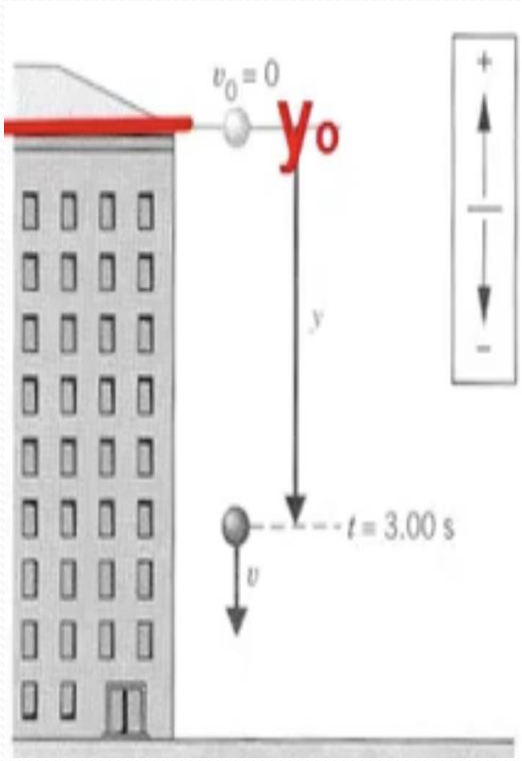
A stone is dropped from rest the top of abuilding ,as shown in the figure .After $3s$ of free fall ,what is the displacement y of the stone.

Solution

$$y=y_0+v_0t-\frac{1}{2}g\,t^2$$

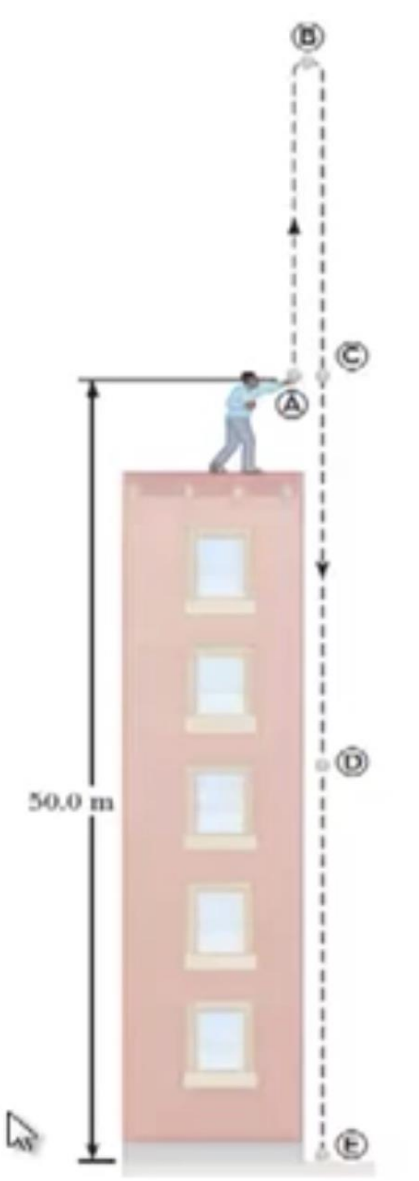
$$y=o+o-\frac{1}{2}\times 9.8\times(3)^2$$

$$y=-44.1m$$



Example (2)

A stone is thrown from the top of the building with an initial velocity of 20 m/s straight upward .
The stone is launched 50 m above the ground.
The stone just misses the edge of the roof on it way down , as showing in this figure .
Determine
A) The time needed for the stone to reach its maximum height
B)The maximum height
C) Determine the velocity of the stone when it returns to the height from which it was thrown.
D)The velocity and position of the stone at t=5sec
E) The time needed for the stone to reach the ground



Solution

(A) Determine the time needed for the stone to reach its maximum height.

$$v = v_0 - g\,t$$

لاحظ ان السرعة عند اقصى ارتفاع تساوي صفر

$$\therefore t = \frac{v - v_0}{-g} \longrightarrow t = t_B = \frac{0 - 20}{-9.8} = 2.04s$$

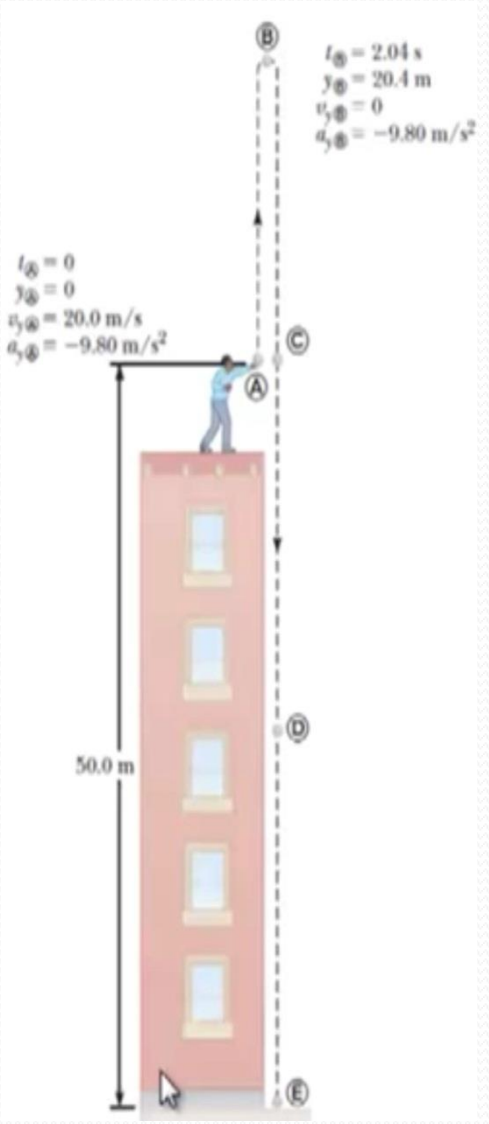
(B) The maximum height

$$y = y_0 + v_0 t - \frac{1}{2} g\, t^2$$

$$y_{max} = y_B = y_A + v_{yA} t - \frac{1}{2} g t^2$$

$$y_B = 0 + 20 \times 2.04 - \frac{1}{2} \times 9.8 \times (2.04)^2$$

$$= 20.4m$$



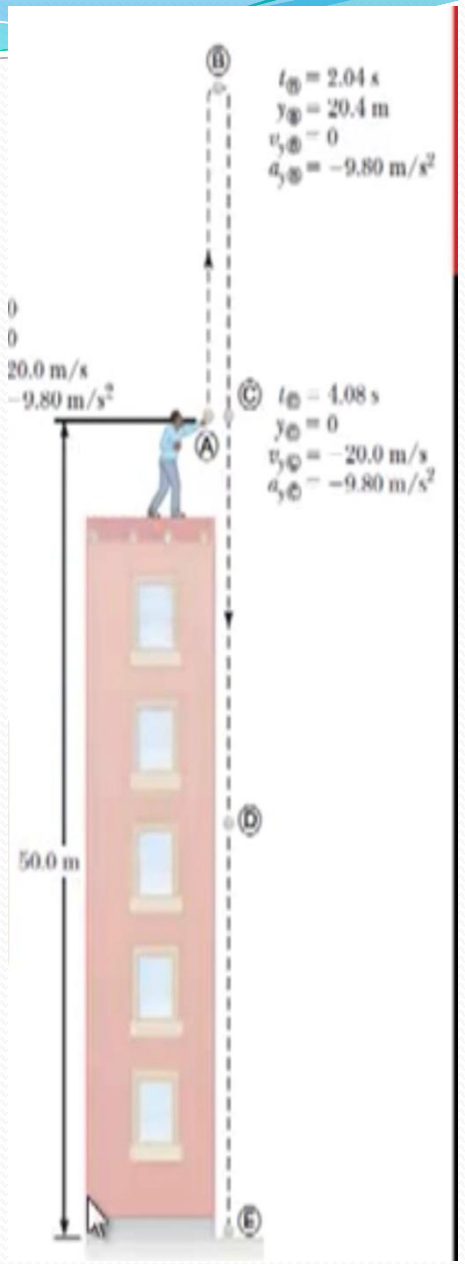
C) Determine the velocity of the stone when it returns to the height from which it was thrown.

$v^2=v_0{}^2-2g(y-y_0)$

$$v_{yc}{}^2 = v_{yA}{}^2 - 2g(y_C - y_A)$$

$$v_{yc}{}^2 = (20)^2 - 2(9.8)(0-0) = 400 m^2/s^2$$

$$v_{yc}=-20 m/s$$



لاحظ ان السرعة هنا تساوي قيمة السرعة الابتدائية واتجاهها للأسفل ودلك لان الحركة تمت في عجلة الجاذبية الارضية وبالتالي زمن الصعود يساوي زمن النزول .

لو اطلق الحجر بسرعة اكبر لكان زمن الصعود اكبر واقصى ارتفاع اكبر

D) Find the velocity and position of the stone at t=5s.

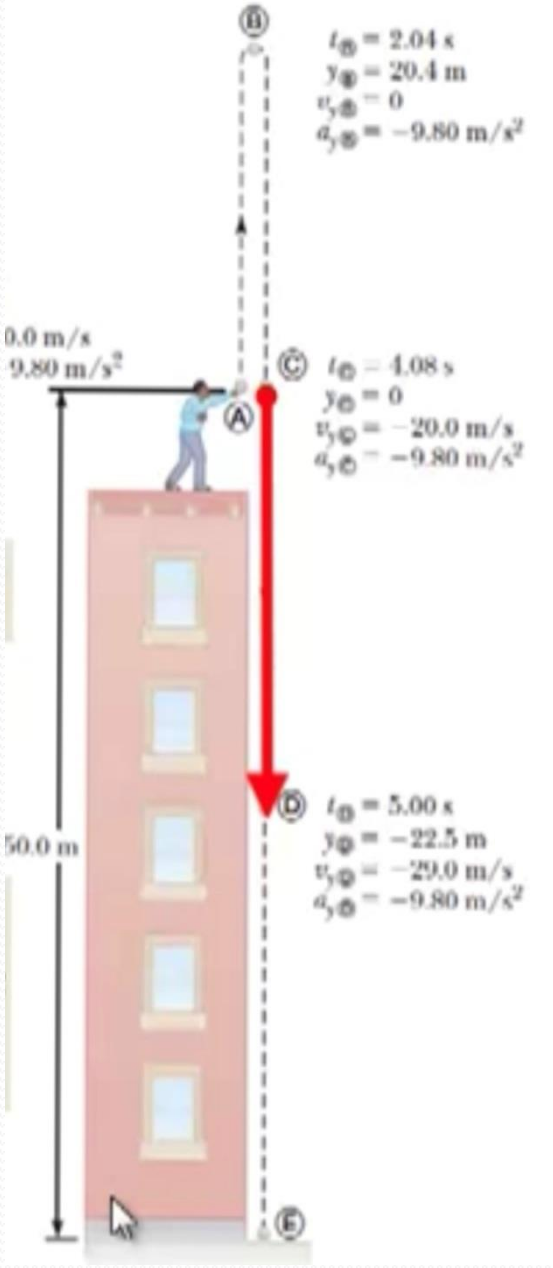
$$v = v_0 - gt$$

$$v_{yD} = v_{yA} - gt = 20 - 9.8 \times 5 = -29m/s$$

$$y_D = y_A + v_{yA}t - \frac{1}{2}gt^2$$

$$y_D = 0 + 20 \times 5 - \tfrac{1}{2} \times 9.8 \times (5)^2 = -22.5m$$

تزداد سرعة الهبوط بسبب تسارع
الارضية الجاذبية



E) Find the time required for the stone to reach the ground

$$y=y_0+v_0t-\frac{1}{2}gt^2$$

$$y = 50m \quad , y_0 = 0$$

$$-50 = 0 + 20t - \frac{1}{2} \times 9.8 \times t^2$$

Apply the quadratic formula and take the positive root:

$$t = 5.83s$$

find the velocity of the stone just before it hit the ground?.

لا يجاد السرعة قبل وصول الحجر نستخدم المعادلة الاولى من معادلات الحركة ونعوض عن الزمن بالزمن الكلي

$$v = v_0 - g\,t$$