Lecture4

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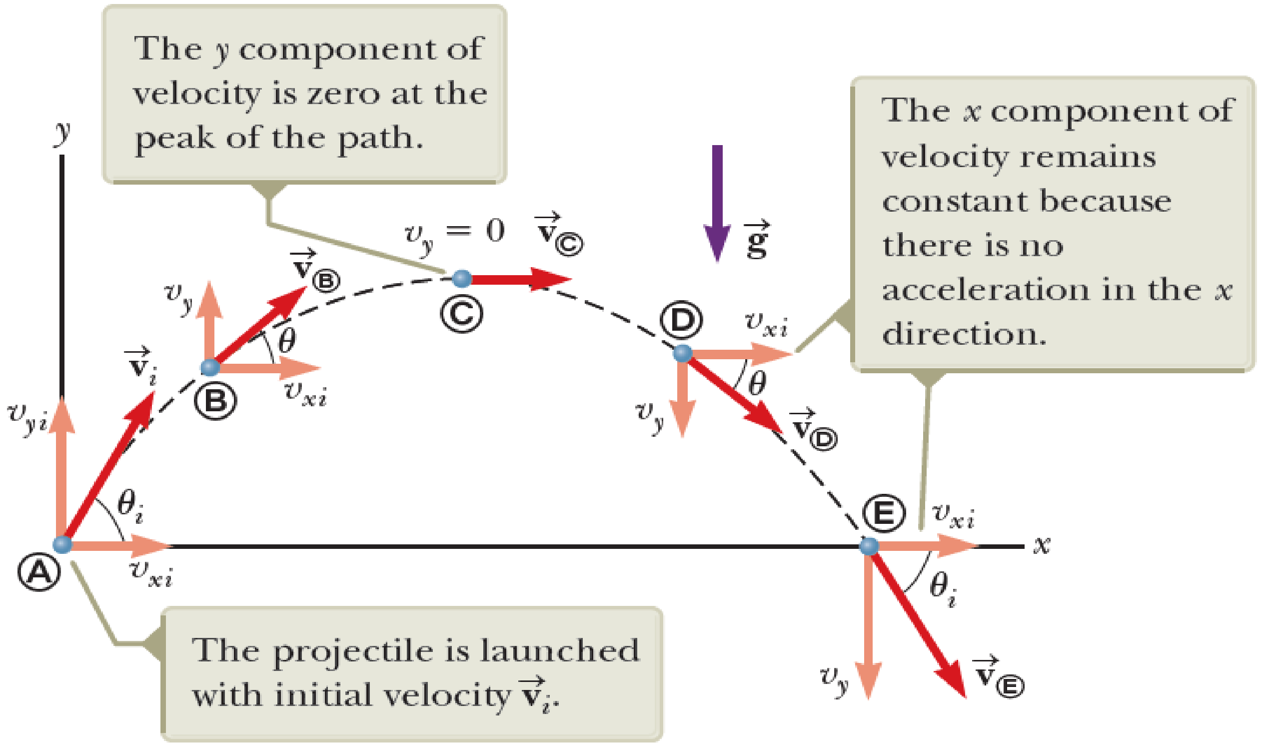
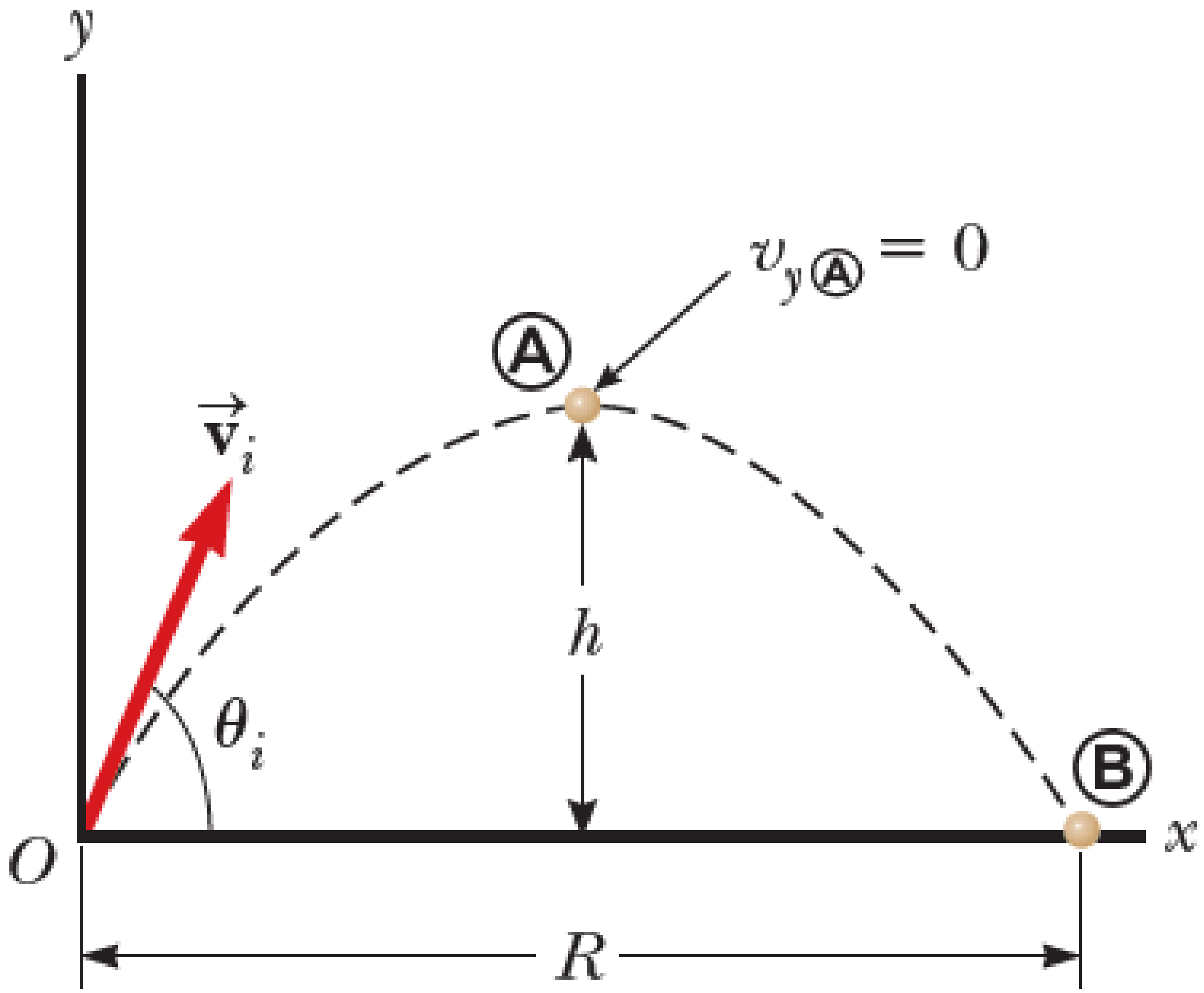
Projectile motion

- Motion in 2D with only the effect of gravity
- The air resistance is negligible (مهمل)



Projectile motion

- Sometimes start with Vi, θ
- Vix = Vi cosθ, Viy = Vi sinθ,
- Apply the laws of motion on each dimension.
- Keep in mind the following:
- ax = 0
- ay = -g = -10 m/s^2
- Vmax y = 0
- No air resistance

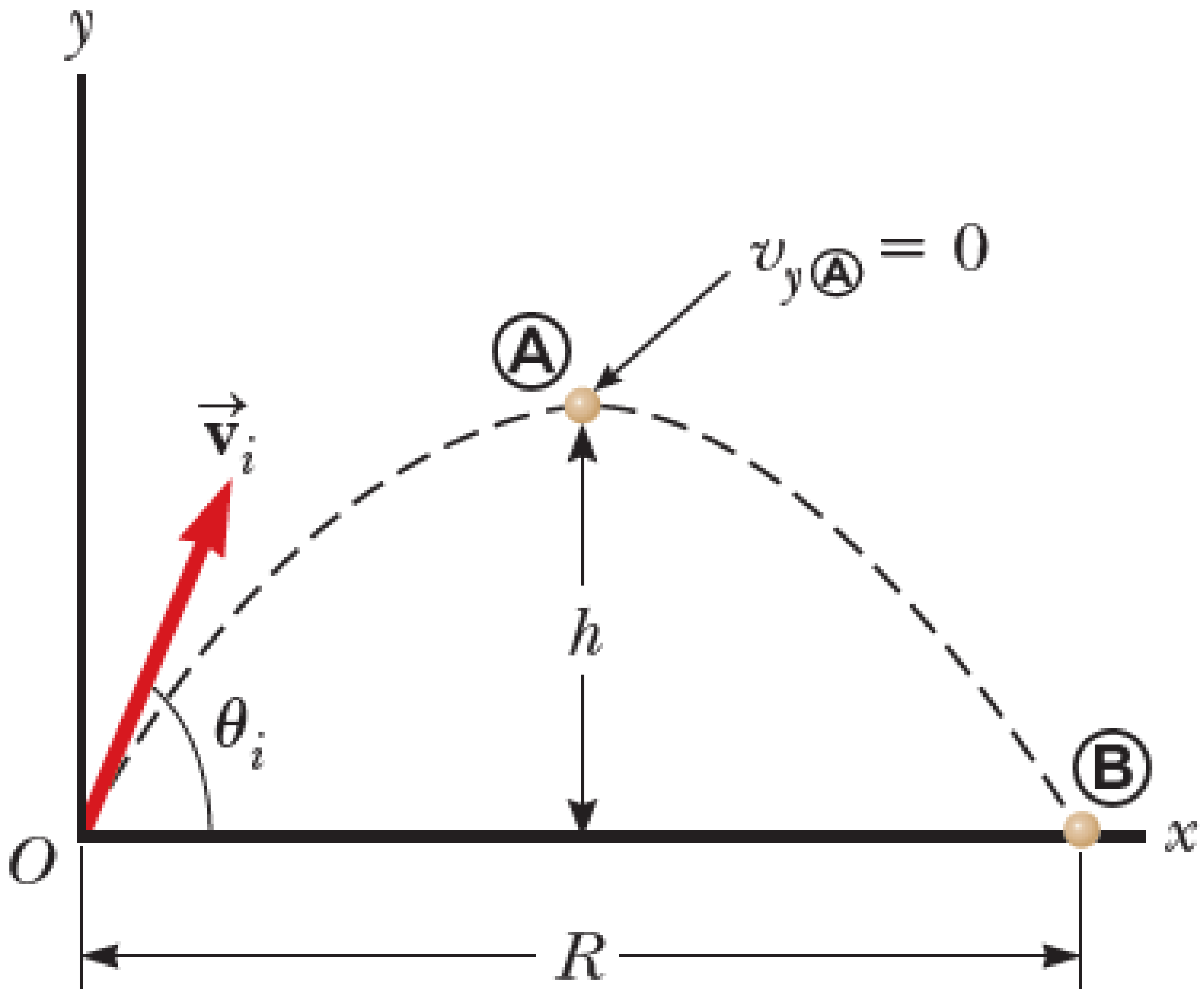


Projectile motion

- $Vx = Vix + ax\, t$, $\Delta x = Vix\, t + 0.5\, ax\, t^2$, $Vx^2 = Vix^2 + 2\, ax\, \Delta x$
- $Vy = Viy + ay\, t$, $\Delta y = Viy\, t + 0.5\, ay\, t^2$, $Vy^2 = Viy^2 + 2\, ay\, \Delta y$
- For x axis:
- $Ax = 0$ ---> $Vx = Vix$, $\Delta x = Vix\, t$, $Vx^2 = Vix^2$
- For y axis:
- $Vy = Viy + ay\, t$, $\Delta y = Viy\, t + 0.5\, ay\, t^2$, $Vy^2 = Viy^2 + 2\, ay\, \Delta y$
- $Vy = Viy – g\, t$, $\Delta y = Viy\, t - 0.5\, g\, t^2$, $Vy^2 = Viy^2 - 2\, g\, \Delta y$
- Get some certain values

Projectile motion

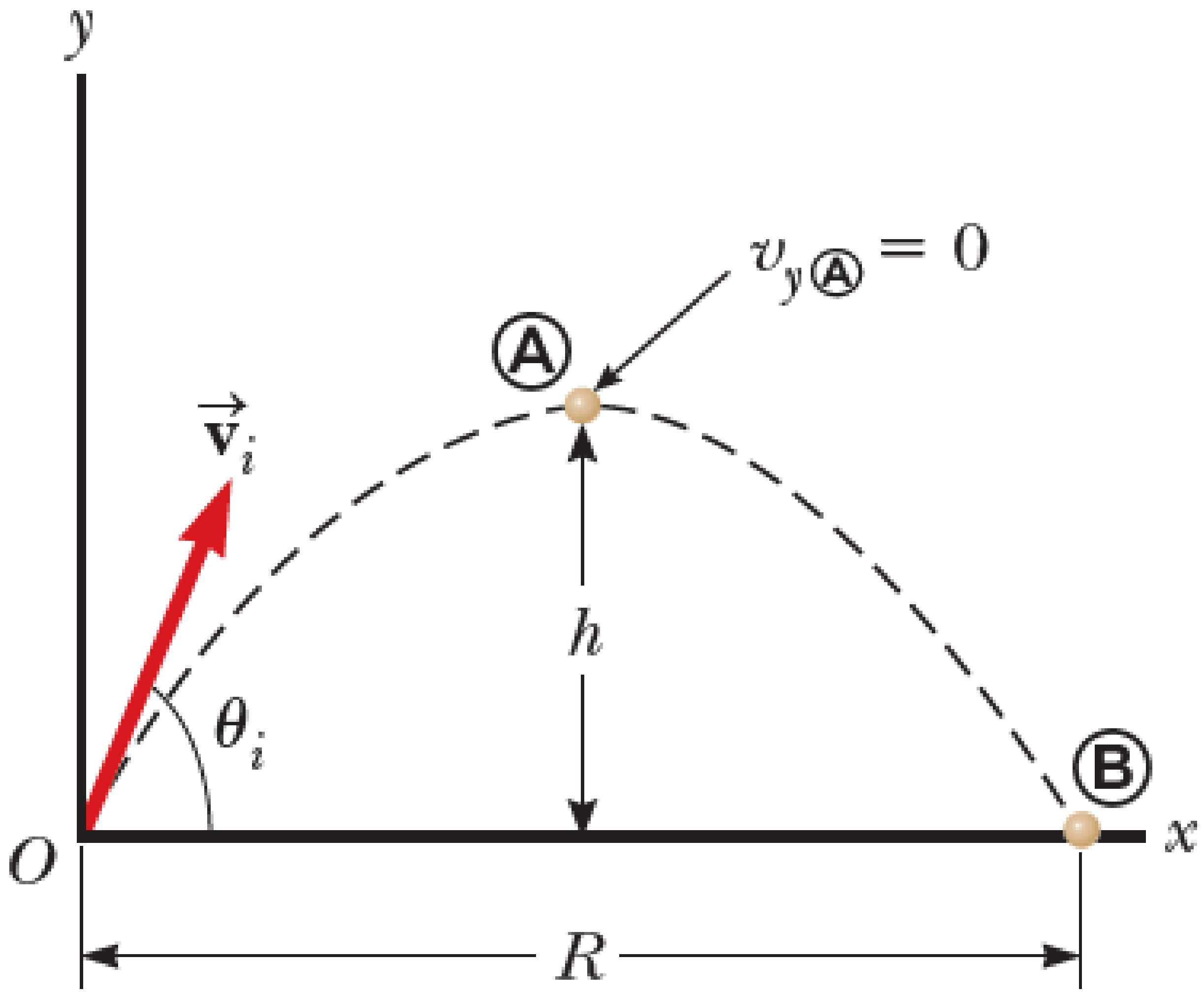
- Maximum (max) height (h)
- $Vy^2 = Viy^2 + 2\ ay\ \Delta y$
- $ay = -g$, $\Delta y = h$, $Vy = 0$



Projectile motion

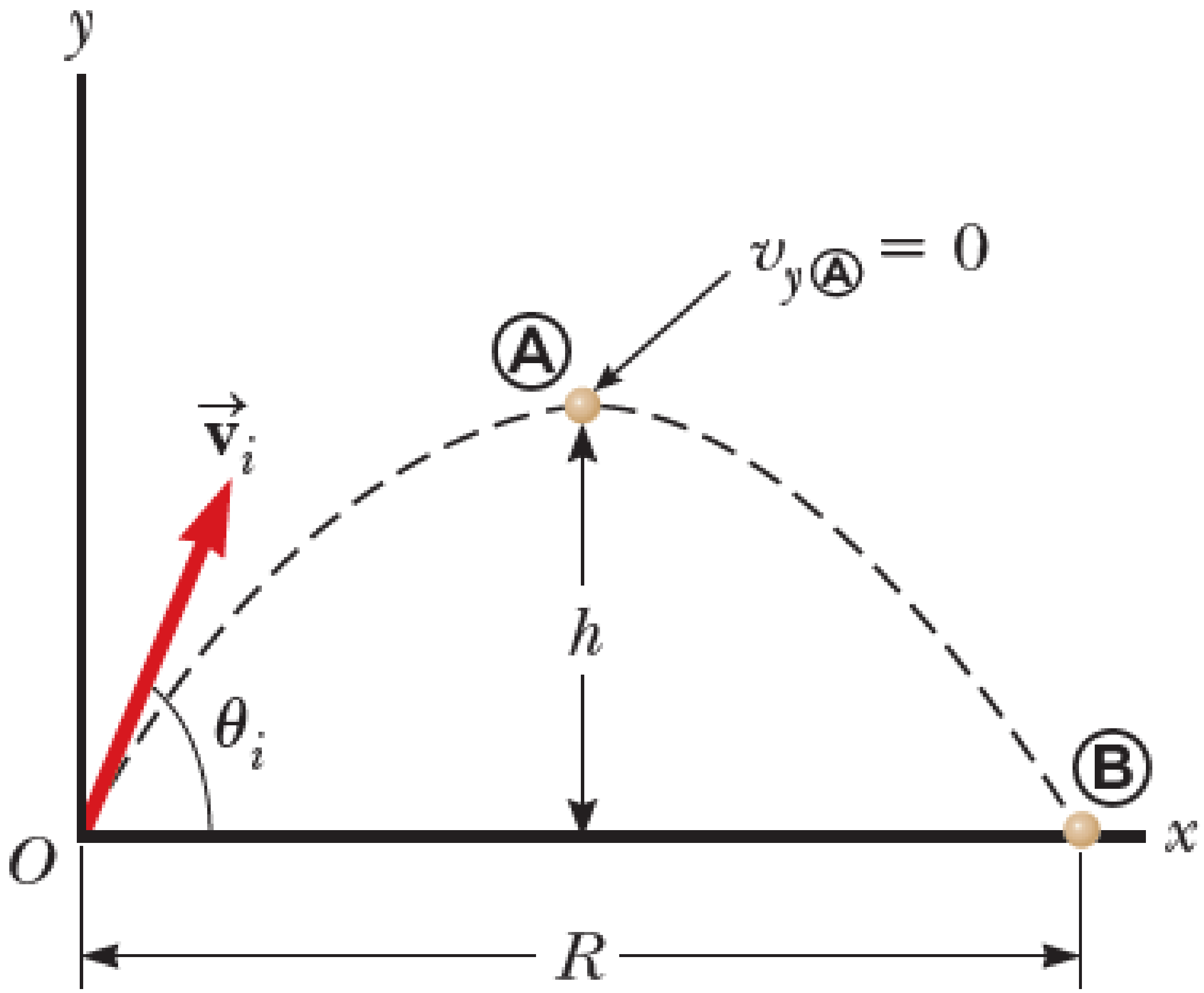
- Time to reach max height (t max)
- At max height (h) ---> Vy = 0
- Vy = Viy + ay t

- Time of the flight (t total)
- T total = 2 t max



Projectile motion

- Range (R)
- Δx = Vix t
- Apply t total



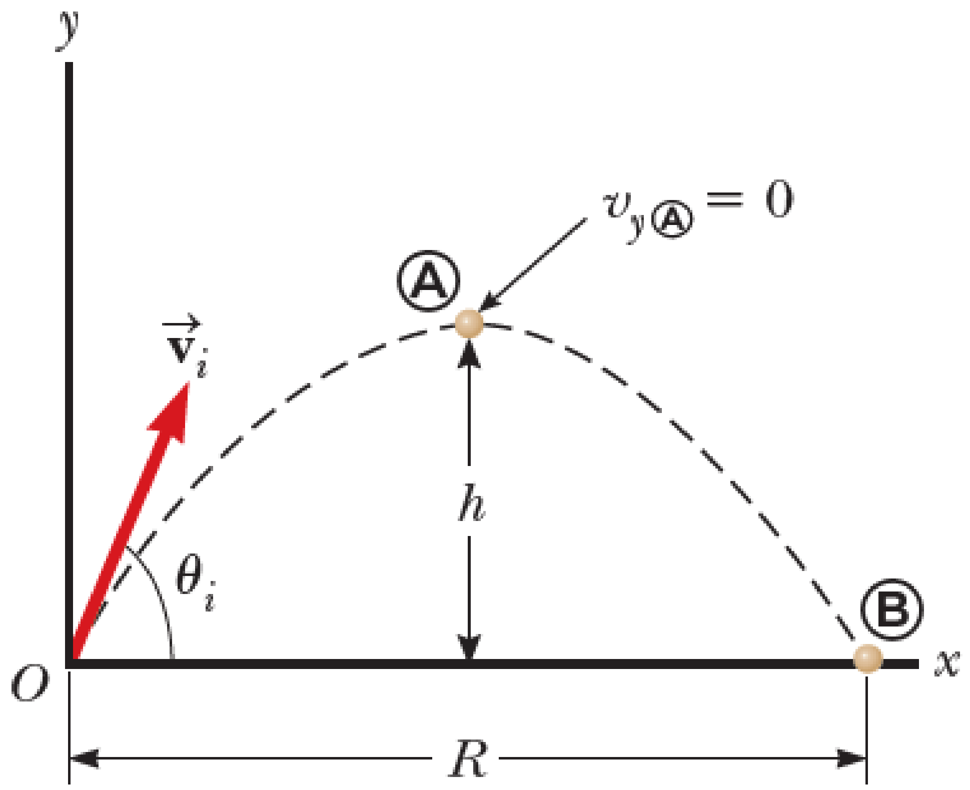
Projectile motion

34. A shell is fired from the ground with an initial speed of 1.70×10^3 m/s (approximately five times the speed of sound) at an initial angle of 55.0° to the horizontal. Neglecting air resistance, find

a. the shell's horizontal range

b. the amount of time the shell is in motion

- Vi = 1.7 x 10^3 m/s = 1700 m/s
- θ = 55
- Time to reach max height (tmax)
- ---> Vy = Viy + ay t
- Vy= 0, Viy = Vi sinθ, ay = -g = -10 m/s^2.
- ---> 0 = Vi sinθ - 10 tmax
- --->0 = (1700) (sin 55) - 10 tmax
- 0 = 1393 – 10 t ---> -1393 = -10 tmax
- ---> tmax = 139.3 s
- ---> t total = 2 tmax ---> t total = 2 x 139.3 = 278.6 s



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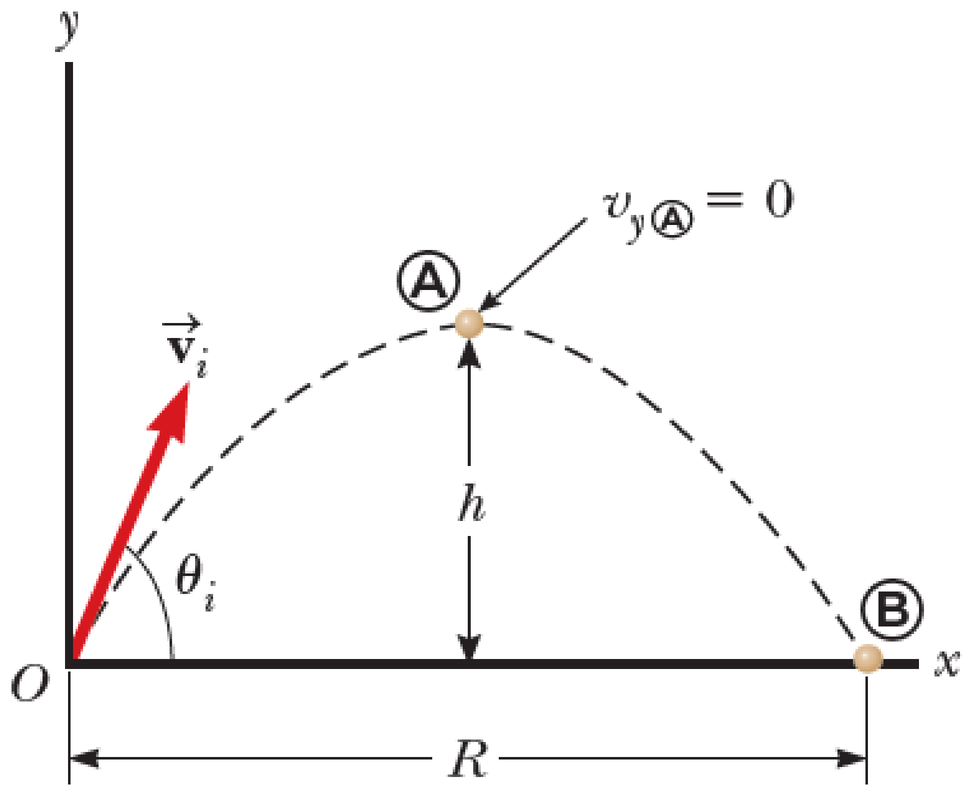

- $V_i = 1.7 \times 10^3$ m/s = 1700 m/s
- $\theta = 55$
- t total = 278.6 s
- For the horizontal range
- $\Delta x = V_{ix}\, t$
- $V_{ix} = V_i \cos\theta = (1700)\cos(55) = 975$ m/s
- $\Delta x = V_{ix}\, t_{total} = (975)(278.6) = 271657$m

Chapter4

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The 1st law of motion

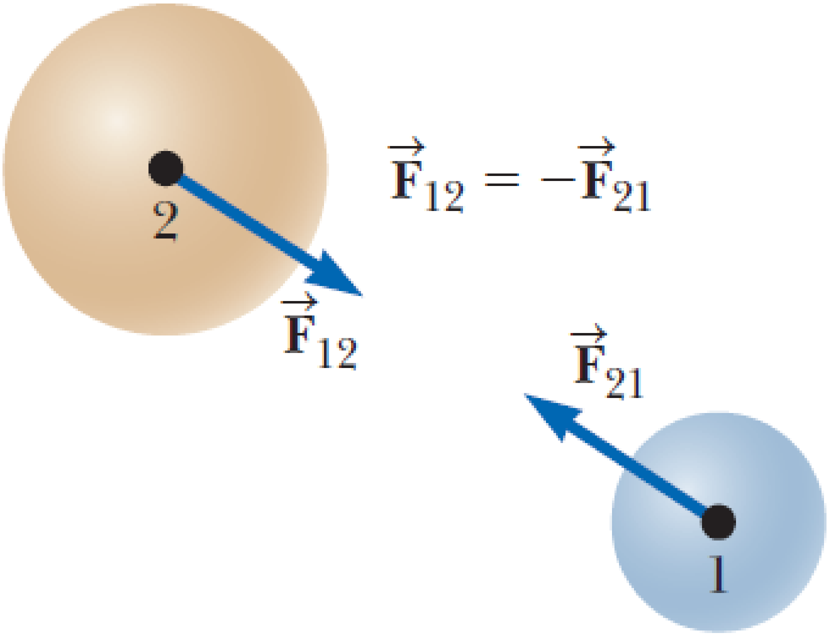
- Different statements
- "An object at rest stays at rest and an object moving keeps moving in the same speed unless a force affects on it that changes the speed or direction or both"
- "When no net force acts of object, the acceleration of the object is zero"
- الجسم الساكن يبقى ساكن والمتحرك يبقى متحرك ما لم تؤثر عليه قوة تغير من اتجاه سرعته او مقدارها او الاثنين معا
- Mass: How much resistance to the motion the object makes.

The 2nd law of motion

- Different statements
- "The acceleration of an object is directly proportional to the net force affecting on an object"
- $\Sigma F = m\,a$
- يتناسب تسارع جسم طرديا مع القوة المؤثرة عليه
- Vector sum for the forces
- Acceleration is a vector, mass is a scalar
- $\Sigma F_x = m\,a_x$, $\Sigma F_y = m\,a_y$
- Mass > 0
- The unit for the force is Newton (N)
- $1N = 1\ kg.\ m/s^2$.

The 3rd law of motion

- Different statements
- "Every action has a reaction equals in magnitude and opposite in direction"
- لكل فعل رد فعل مساو له في المقدار ومعاكس له في الاتجاه
- $F_{12} = - F_{21}$ (vectors)
- F12: Force exerted by object 1 on object 2

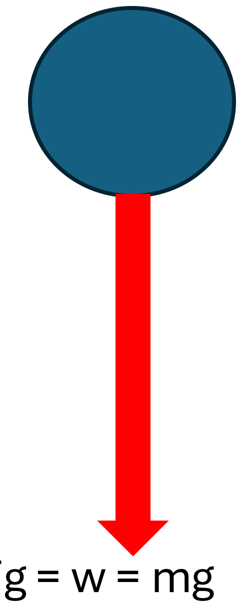


The equilibrium state

- If a system is in equilibrium ---> $\Sigma F = 0$ ---> $\Sigma Fx = 0$ and $\Sigma Fy = 0$
- Does it mean the object is always not moving ? NO
- Can be moving with zero net force ---> $a = 0$ ---> constant speed

Free-fall & weight

- If an object is free-falling ---> affected by earth gravitational force
- $\Sigma F = m\,a$ ---> $Fg = m\,g$
- Fg is called weight (unit is Newton)
- Always affecting downward
- g: free-fall acceleration (acceleration due to gravity)
- $g = 10\ m/s^2$. (In this course)

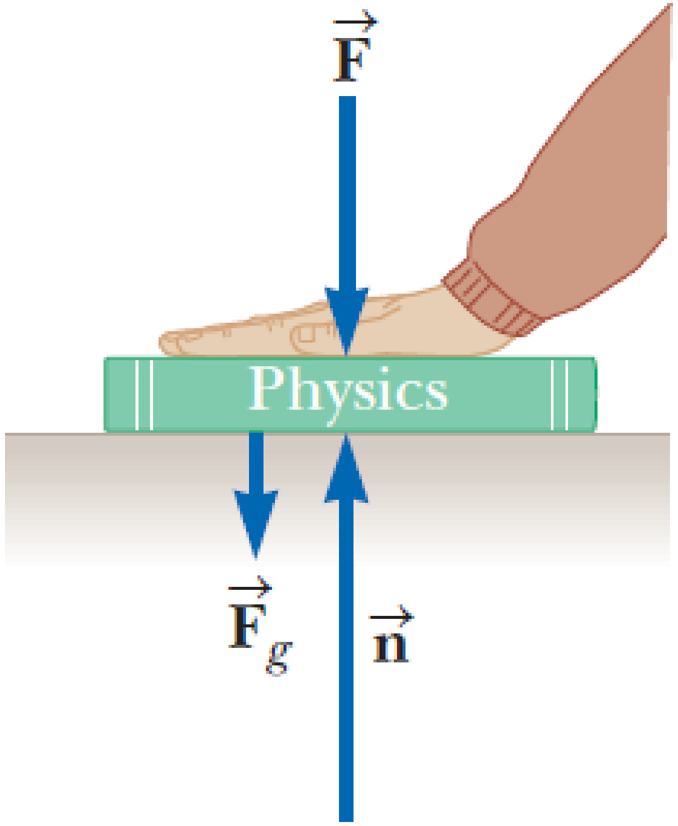


The free-body diagram

- Draw the forces affecting on an object (force diagram)
- Important in solving problems

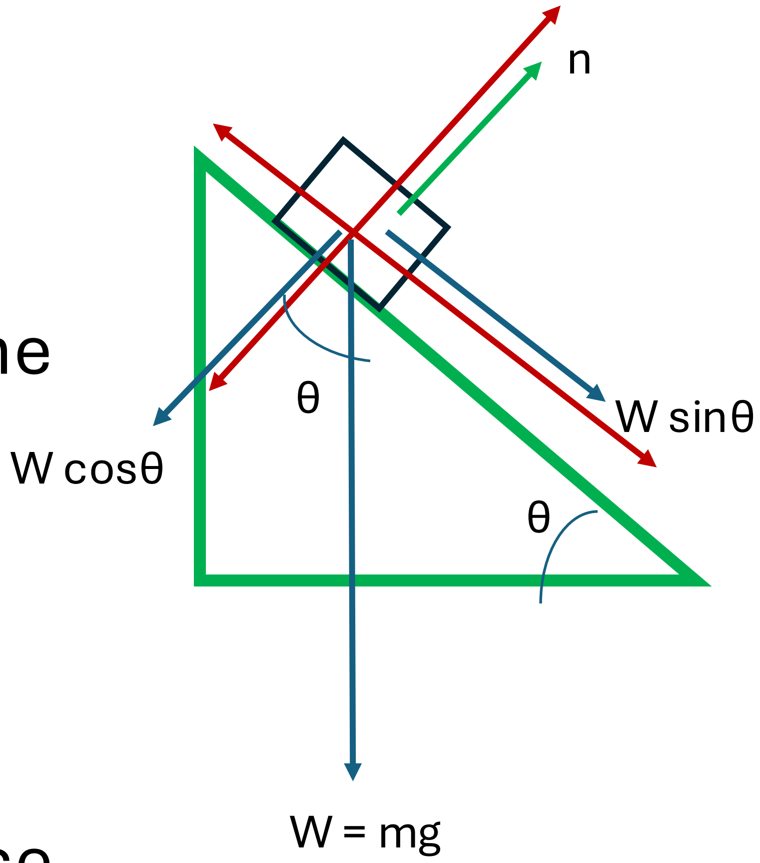
The normal force

- If an object is sitting on the ground, table, ...
- ---> There is a force downward called weight
- ---> there is a reaction force normal (perpendicular) to the surface in the opposite direction
- This is called normal force
- Example : if you affect with a force F on a book sitting on a table and the book is not moving---> there is a reaction force upward (n)
- $\Sigma F = m\,a$ ---> $n - F - w = m\,a$
- The book is not moving ---> $n - F - w = 0$



The inclined plane

- For the inclined plane:
- First get the forces in the diagram then write the laws
- $\Sigma F = m\,a$ ---> $\Sigma F_x = m\,a_x$, $\Sigma F_y = m\,a$
- The weight is always perpendicular
- (as shown in the figure)
- The normal force has 90° angle with the surface



The inclined plane

- Example:
- The box in the figure has a mass 2 kg and the angle is 30°. What is the box acceleration on the inclined plane?
- According to Newton's 2nd law
- ---> $\Sigma Fx = m\, ax$
- In the x axis the only force affecting is W sinθ
- ---> $\Sigma Fx = W \sin\theta = m\, ax$
- $W = m\, g$ ---> $m\, g \sin\theta = m\, ax$
- ---> $(2)\,(10)\,\sin(30) = 2\, ax$
- ---> $10 = 2\, ax$ ---> $ax = 5\ m/s^2$.