Projectile Motion

Reading Supplemental Textbook Material Chapter 13

Pages 288-295

Newton's first law

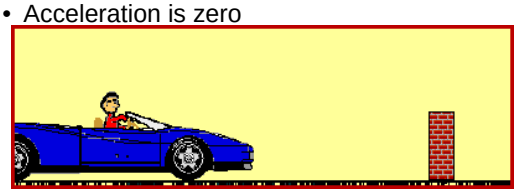
An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

Newton's First Law

- Objects at rest stay at rest
- Acceleration is zero

Newton's First Law

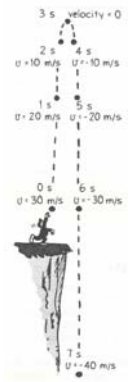
- Objects in motion stay in motion
- Keep going same speed and direction
- Acceleration is zero



http://www.physicsclassroom.com/mmedia/newtlaws/cci.gif

Acceleration of Gravity

- Loses speed for each interval of time it rises on an upward throw
- Gains at same rate on its downward path



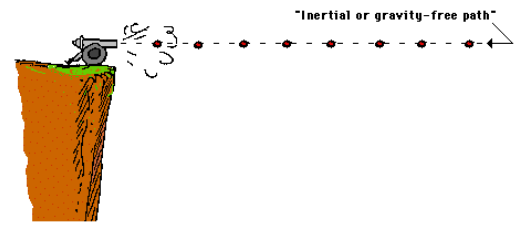
Vertical Projectile

- If a projectile is shot into the air, what is its acceleration in the vertical direction?
- What is its acceleration in the horizontal direction?
- In what position will its speed be at a minimum?

Vertical Projectile solution

- If a projectile is shot into the air, what is its acceleration in the vertical direction?
  - **~ -10 m/s^2**
- What is its acceleration in the horizontal direction?
  - **zero**
- In what position will its speed be at a minimum?
  - **At the top of its trajectory**

Cannonball without gravity



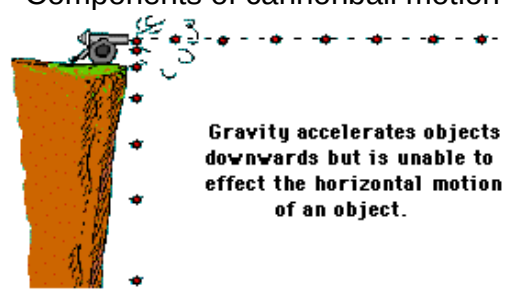
Without gravity, an object in motion will continue in motion with the same speed and in the same direction.

http://www.physicsclassroom.com/Class/vectors/U3L2a.html

There is gravity

- This is the outside force acting on the object to change its course

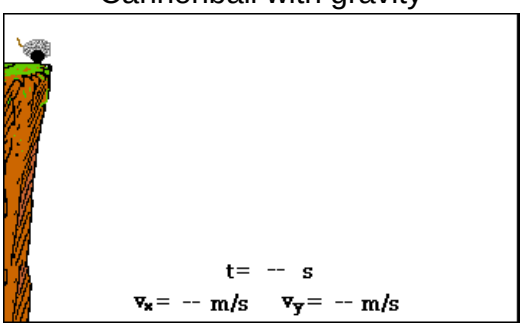
Components of cannonball motion



Gravity accelerates objects downwards but is unable to effect the horizontal motion of an object.

http://www.physicsclassroom.com/Class/vectors/u3l2b.html

Cannonball with gravity



http://www.physicsclassroom.com/mmedia/vectors/hlp.gif

Airplane and Package

- Flying straight and level at 45 m above ground level, at a speed of 40 m/s
- Drops package, which falls to the ground
- Where will package land? (neglect air resistance)

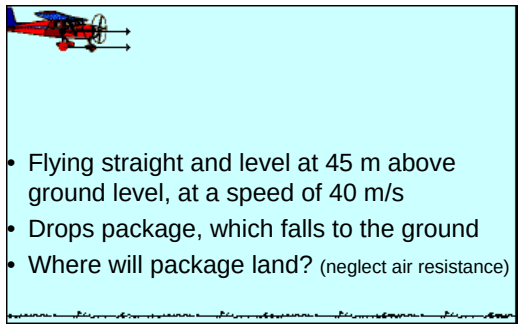
http://www.physicsclassroom.com/mmedia/vectors/pap.gif

Airplane and Package

- Flying straight and level at 45 m above ground level, at a speed of 40 m/s
- Drops package, which falls to the ground
- Where will package land? (neglect air resistance)

a) Straight down from where it was dropped
b) Underneath plane
c) 80 m behind plane
d) More than 120 m behind plane

Airplane and Package



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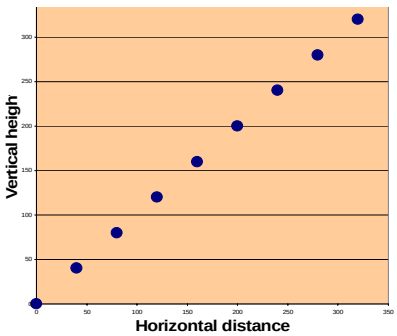
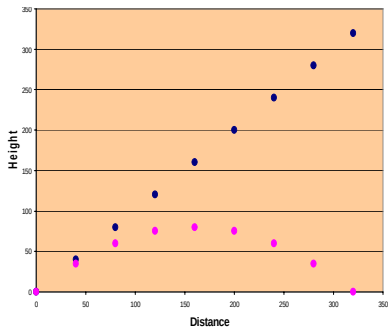
http://www.physicsclassroom.com/mmedia/vectors/pap.gif

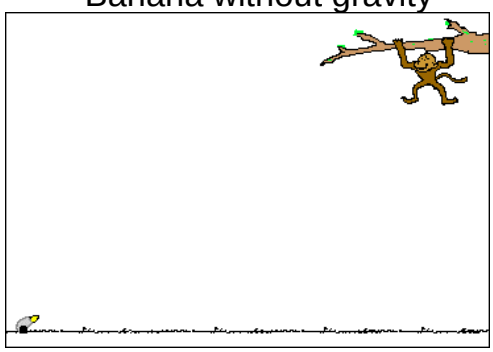
Cannonball without gravity



Cannonball with gravity



Banana without gravity



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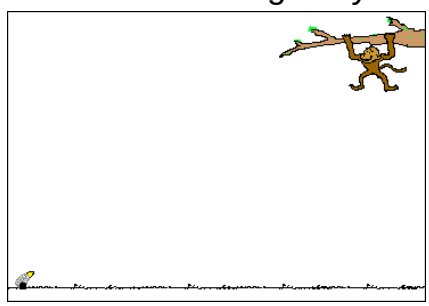
Banana with gravity



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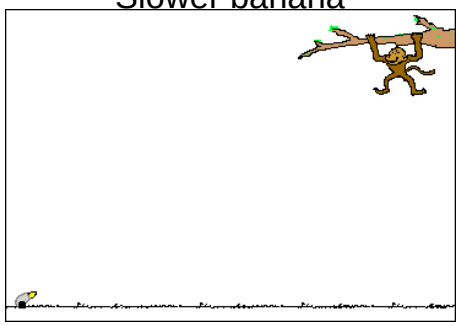
Slower banana

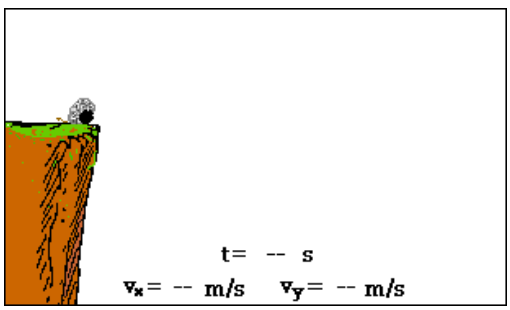


http://www.physicsclassroom.com/mmedia/vectors/mzs.html

How Fast is it going?

- Horizontal Speed does not change
- Vertical speed function of time
  - How fast was it going up to begin with
  - This changes due to acceleration of gravity

How Fast is it going?



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How Fast is it going?

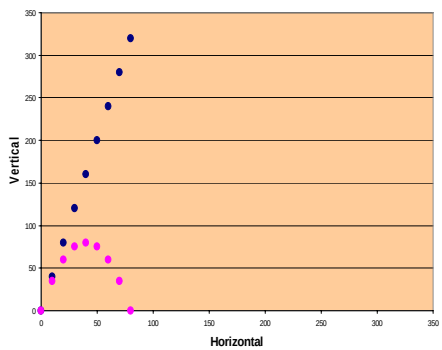
- Horizontal Speed does not change
- Vertical speed function of time
  - How fast was it going up to begin with
  - This changes due to acceleration of gravity

$$v_0$$

$$v = gt$$

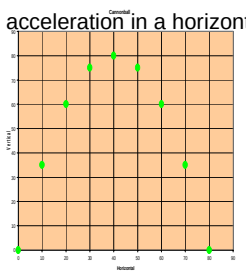
$$v_0 \pm v_{change}$$

Steeper Cannonball



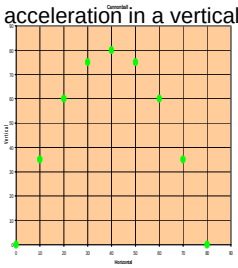
Acceleration of Cannonball

- What is the acceleration in a horizontal direction?

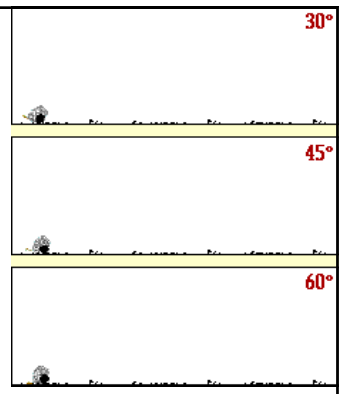


Acceleration of Cannonball

- What is the acceleration in a vertical direction?



Projectile Range



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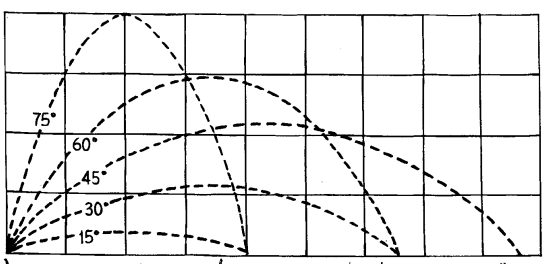
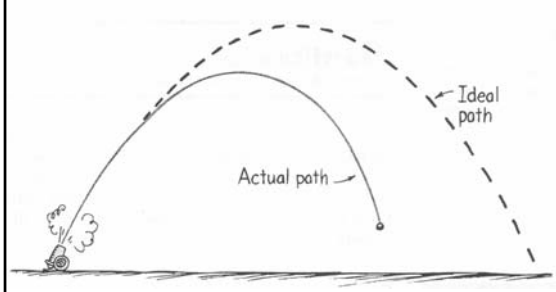
Cannonball Trajectories



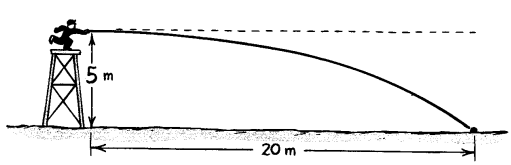
Cannonball trajectories

- Projectile will fall from maximum height in same amount of time it took to rise
- Because the acceleration of gravity slows it at the same rate it increases the speed on the way down

With air resistance



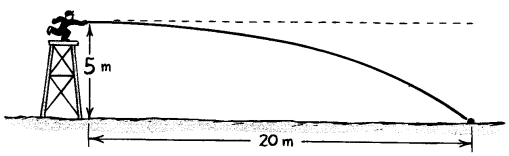
Calculations of distance, speed and acceleration



How fast was this ball thrown?

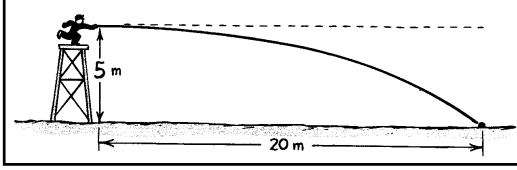
How fast was ball thrown?

- Want to find d_{horz}/t,
- We can calculate t
- $d_{vert} = (½)\ gt^2$,
- We know d_{horz}, d_{vert}, g



How fast was ball thrown?

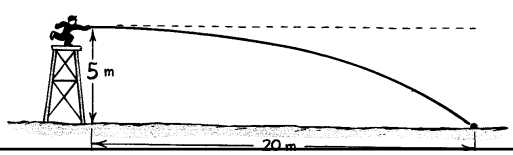
- $d_{vert} = (½)\ gt^2$
- d_{vert}, = 5 m
- g = 10 m/s^2



Solve for how long to fall

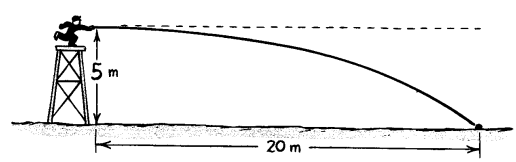
$$d = \frac{1}{2}gt^2 \qquad 5m = \frac{1}{2}\left(\frac{10m}{s^2}\right)t^2$$

$$t^2 = \frac{5m}{\frac{1}{2}\left(\frac{10m}{s^2}\right)} \qquad t = \sqrt{\frac{5m}{\frac{1}{2}\left(\frac{10m}{s^2}\right)}} = 1s$$

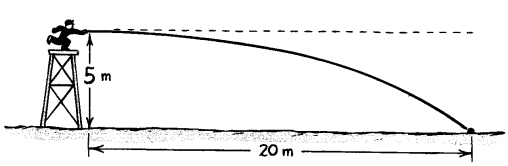


How fast was ball thrown?

- Want to find v
- $v = d_{horz}/t$
- We calculated t = 1s
- Distance=20 m
- v = 20 m/1 s v=20 m/s



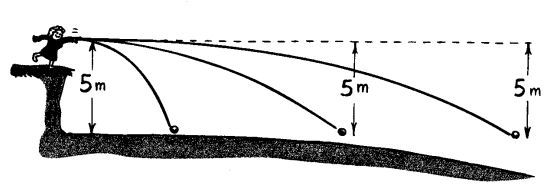
How fast was ball thrown?



$$\frac{20m}{s}\cdot\frac{60s}{\min}\cdot\frac{60\min}{h}\cdot\frac{1km}{1000m}\cdot\frac{0.62mi}{1km} = 44.6mi/h$$

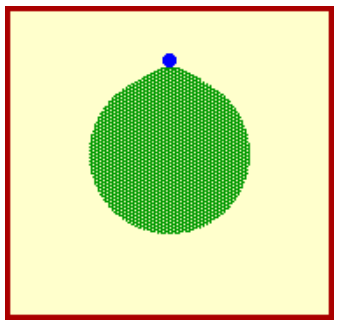
Object thrown horizontally

- Falls the same distance in the same time, no matter the speed of the throw



Satellite as projectile

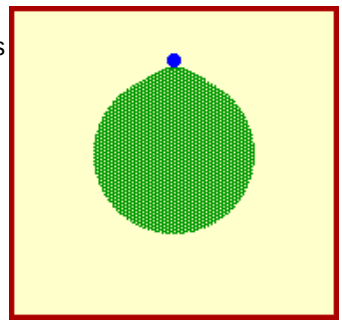
No gravity



No gravity http://www.physicsclassroom.com/mmedia/vectors/tp.gif

Satellite as projectile

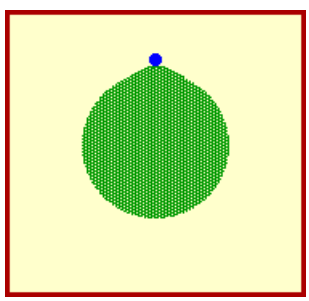
6000 m/s



6000 m/s http://www.physicsclassroom.com/mmedia/vectors/6kms.gif

Satellite as projectile

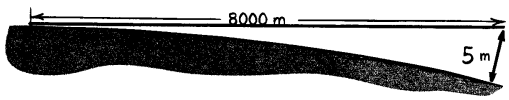
8000 m/s



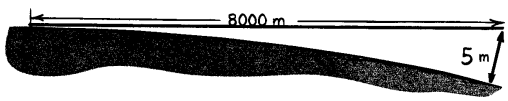
8000 m/s http://www.physicsclassroom.com/mmedia/vectors/co.gif

Object thrown horizontally

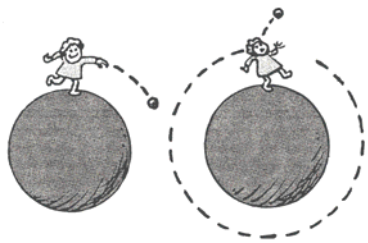
- Falls the same distance in the same time, no matter the speed of the throw
- Earth's surface is 5 meters lower for every 8000 meters horizontal distance



- Earth's surface is 5 meters lower for every 8000 meters horizontal distance
- If it is thrown 8000m/s, it will never reach the surface
- Because it falls just as fast as the surface departs from a horizontal path

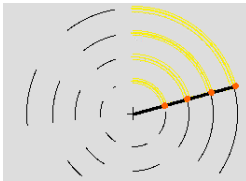


- If it is thrown 8000m/s, it will never reach the surface (nearly 18,000 mi/h)
- Because it falls as fast as the surface departs from a horizontal path



Rotational speed

- Revolutions per time unit
- Objects near center have lower speed than those near edge
- Speed is directly proportional to distance from center



http://www.glenbrook.k12.il.us/GBSSCI/PHYS/CLASS/circles/u6l1a.html

Rotational Speed

- Speed half way from the center is 2 m/s
- What is the speed at outer edge?

Rotational Speed

- Cups roll in circles because the wider part of cup has greater speed than narrower part
- It goes further for the same amount of time
- Train wheels stay on track for the same reason.

Newton's Laws of Motion

- First Law: Every object continues in its state of rest, or uniform motion in a straight line, unless it is compelled to change that state by forces impressed upon it.
- Inertia

Newton's Laws of Motion

- Second Law: The acceleration of an object is directly proportional to the net force acting on the object, is in the direction of the net force, and is inversely proportional to the mass of the object.

Newton's Laws of Motion

- Third Law: Whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.

- Physics Tutorial Website

  http://www.physicsclassroom.com/Default2.html