FALLING OBJECTS & PROJECTILES

PES 1000 – PHYSICS IN EVERYDAY LIFE

HORIZONTAL MOTION: NO ACCELERATION

- Imagine that we placed an apple on an icy surface with no friction and gave it a little sideways push.
- Since there is no acceleration (after we have pushed it), we would observe the following behavior:
  - The apple would move with an ***unchanging speed***.
  - It would travel the ***same distance*** with every second that passed

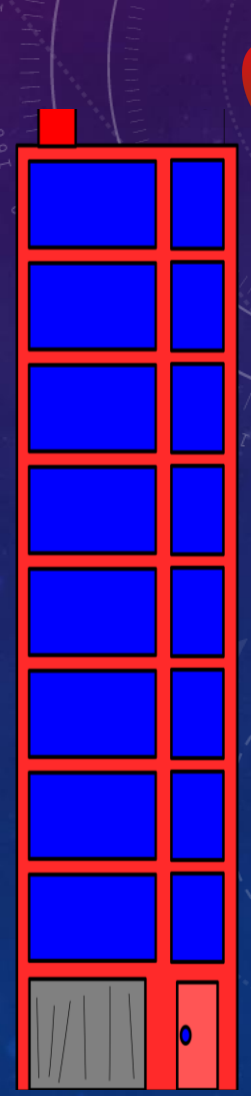
HORIZONTAL MOTION: NO ACCELERATION

- For a numerical example, we would use the equations for zero acceleration from a previous lecture
  - The speed at each time is the same. If it started at 1 m/s, for instance, it would remain at 1 m/s.
  - The equation to find the distance travelled at each second is:
    distance (sideways) = speed * time

Time (s)	Acceleration (m/s^2)	Speed (m/s)	Distance travelled (m)
0	0	1	0
1	0	1	1
2	0	1	2
3	0	1	3

DROPPING AN OBJECT FROM REST

- Imagine instead dropping the apple from a tall building, releasing it without throwing it.
- We will make the following assumptions:
  - Air resistance is negligible, and will be ignored
  - Initial velocity will be zero.
  - Gravitational acceleration is constant for the entire drop. The value of acceleration is about ***9.81 m/s per second***
  - There is no wind or any other sideways accelerating forces



DROPPING AN OBJECT FROM REST

- We would observe the following behavior:
  - The apple would have a ***constantly increasing speed***
  - The apple would fall a ***farther and farther distance every second*** that passed
- Note: under these assumptions, **all** objects will fall at same rate, regardless of their weight!

VERTICAL MOTION: CONSTANT ACCELERATION

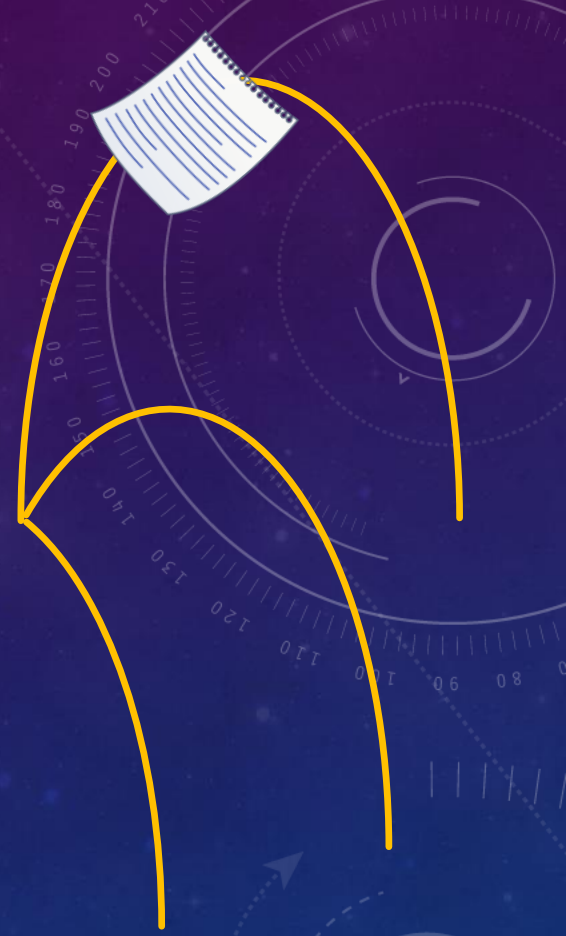
- The dropped apple would fall an increasing distance every second
- For a numerical example, we would use the equations for constant acceleration from a previous lecture
  - The equation to find the speed at each second is: speed = (9.8 m/s^2) * time
  - The equation to find the distance fallen at each second is: y = ½ (9.8 m/s^2) * $time^2$

Time (s)	Downward Acceleration (m/s^2)	Downward speed (m/s)	Distance fallen (m)
0	9.8	0	0
1	9.8	9.8	4.9
2	9.8	19.6	19.6
3	9.8	29.4	44.1

COMBINING BOTH HORIZONTAL AND VERTICAL

- Now imagine that you are back at the top of the building and you throw the apple horizontally off of the side.
- We would observe a combination of the vertical and horizontal motions just described
- The path of the apple would follow a parabola, and this is called a ***parabolic trajectory***.

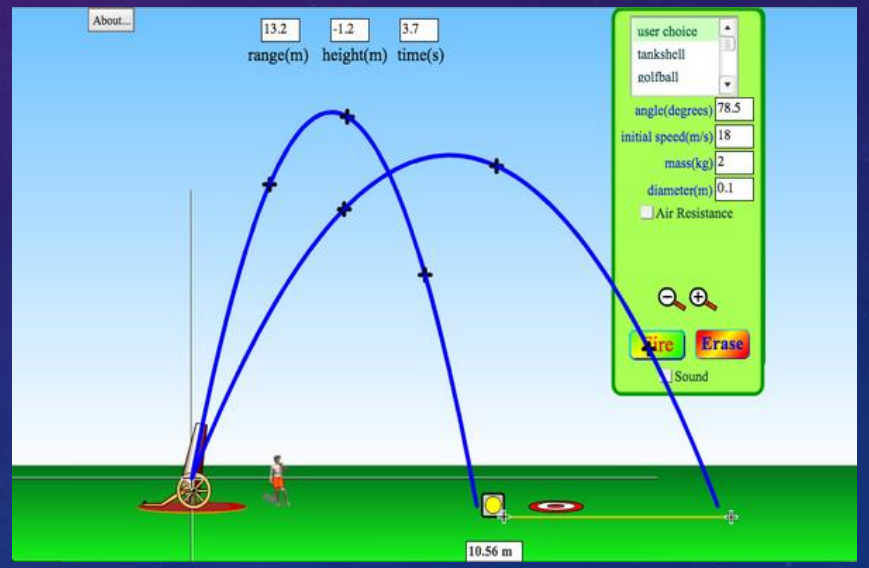
PARABOLIC MOTION



- Any thrown, launched, or fired object near the Earth's surface follows a parabolic trajectory if air resistance is ignored.
  - The object may follow just part of a parabola, depending on its launching conditions
- Ignoring air resistance makes sense when the object is dense relative to the air. Feathers, pages of paper, etc. are not dense relative to the air, so they 'float' down.
- With air resistance, or drag, included:
  - The path of thrown objects is no longer a parabola, although it looks similar
  - A dropped object reaches a maximum speed, called ***terminal velocity***, where the force of drag is equal but opposite the weight, and acceleration is zero.

PARABOLIC MOTION SIMULATION

- The ‘Parabolic Motion’ simulation lets you experiment with parabolic trajectories with and without air resistance
- It can be found here: https://phet.colorado.edu/en/simulation/legacy/projectile-motion
- Let’s play with the simulation:



CONCLUSION

- Objects with zero acceleration have a constant speed
- Objects with constant acceleration have an increasing speed
- Falling objects (projectiles) experience a combination of
  - Sideways motion with zero acceleration
  - Vertical motion with constant acceleration (gravitational) of 9.81 m/s^2
- Projectile motion ignoring air resistance follows a parabola-shaped path.