A ball thrown upward returns to the ground. What are the magnitude and direction of the velocity at different points of the flight?

The velocity vectors at different points in the flight of a ball thrown upward with a starting velocity of +20 m/s.
Example: How high up can the fastest pitcher throw a ball? How long would it be in the air?

**PROJECTILE MOTION**

**Question:** If I throw a ball horizontally, what happens?

- How long does it take to hit the ground?
- Does this depend on the speed with which I throw it?
- If I throw a ball horizontally while simultaneously dropping one which hits the ground sooner?

**Horizontal and Vertical Motion are Independent**

- Constant Motion (no acceleration)
- Horizontal: \(d = v_0t\) (range)
- Vertical: \(d = v_0y t + \frac{1}{2}gt^2\) (height)
The horizontal and vertical motions combine to produce the trajectory of the projected ball.

The total velocity at any point is found by adding the vertical component to the horizontal component.

Trajectories for different initial velocities of a ball rolling off a table: $v_3$ is larger than $v_2$, which in turn is larger than $v_1$. 
PROJECTILE MOTION

Example: Throwing a ball at an angle from a hilltop

What is the distance down range from the base of a hill 30 m high if a ball is thrown up at a 50° angle above the horizontal at 40 m/s? What is the time of flight? What is the maximum height?

\[ \text{Range} = R \]

To calculate the downrange distance, we need to calculate the time the ball is in the air. The time is determined from vertical (y) motion.

\[ v_{0y} = v_0 \sin 50° \]

Once we know the time in the air, we can calculate how far down range it will travel in that amount of time.

Main Points from Today’s Lecture

- Throwing an object upwards
- You should know how to find out how high up it will go, and how long it stays in the air
- Projectile Motion
- You should understand that the horizontal and vertical motion for a projectile are independent
- You should be able to calculate how far down range a projectile will travel if it is thrown at a given speed and angle
HW

Q8, Q10, Q11, Q12, Q14, Q16, Q17, Q23*, Q23*, Q25, Q26, E3, E7, E8, E11, E13