Conceptual Physics I
Classical Mechanics

Lesson 2B – Projectile Motion

Lesson 2B - Projectile Motion

- A projectile is an object that is launched into the air and receives no further propulsion. It then moves under the influence of gravity only (in the absence of air friction).
- The one-dimensional motion (dropping, throwing upwards, throwing downward) we have been considering is a special case of projectile motion.
- We will now look at the curved path that an object takes when launched in the air.

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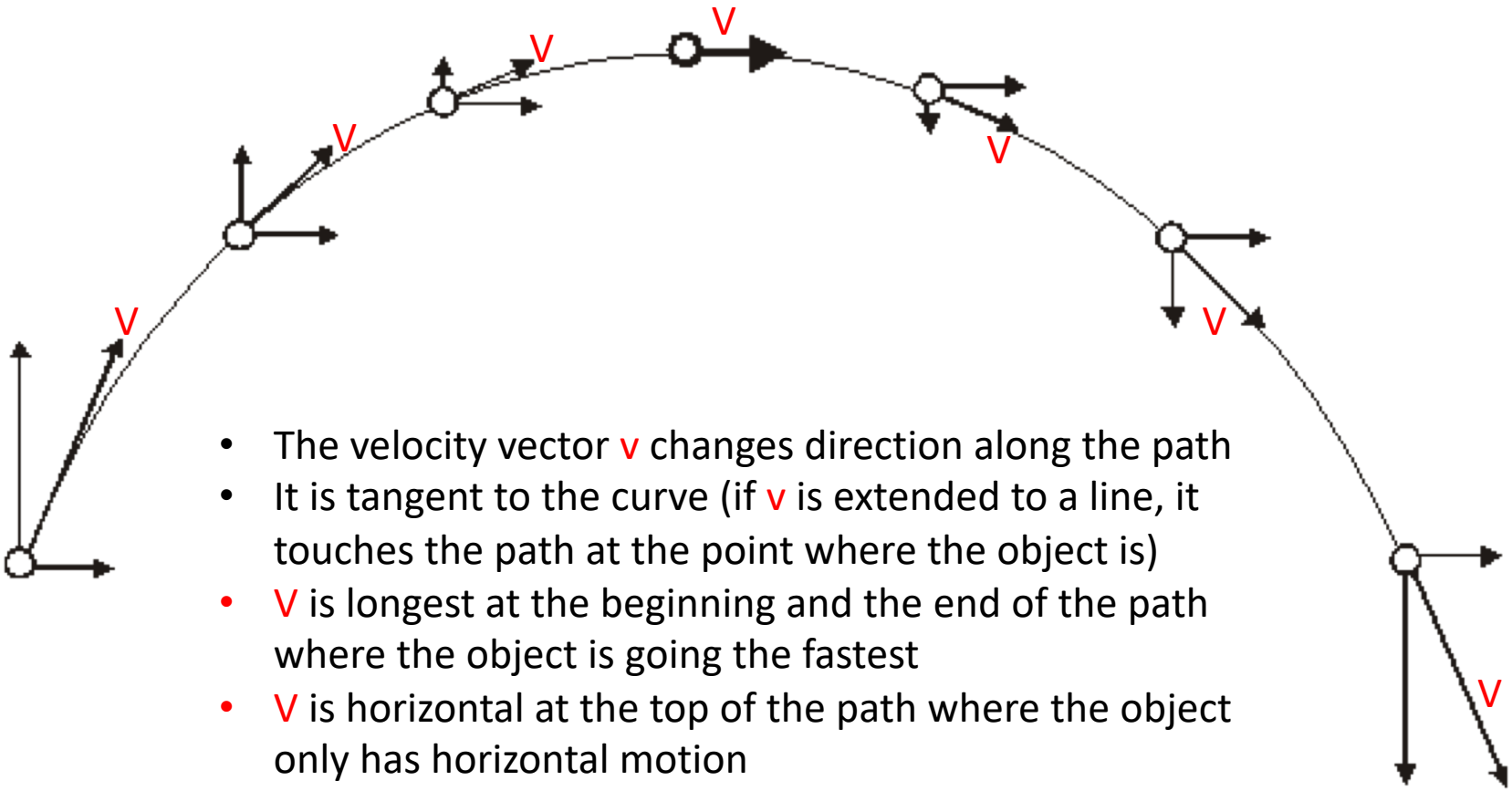

- The velocity vector v changes direction along the path
- It is tangent to the curve (if v is extended to a line, it touches the path at the point where the object is)
- V is longest at the beginning and the end of the path where the object is going the fastest
- V is horizontal at the top of the path where the object only has horizontal motion

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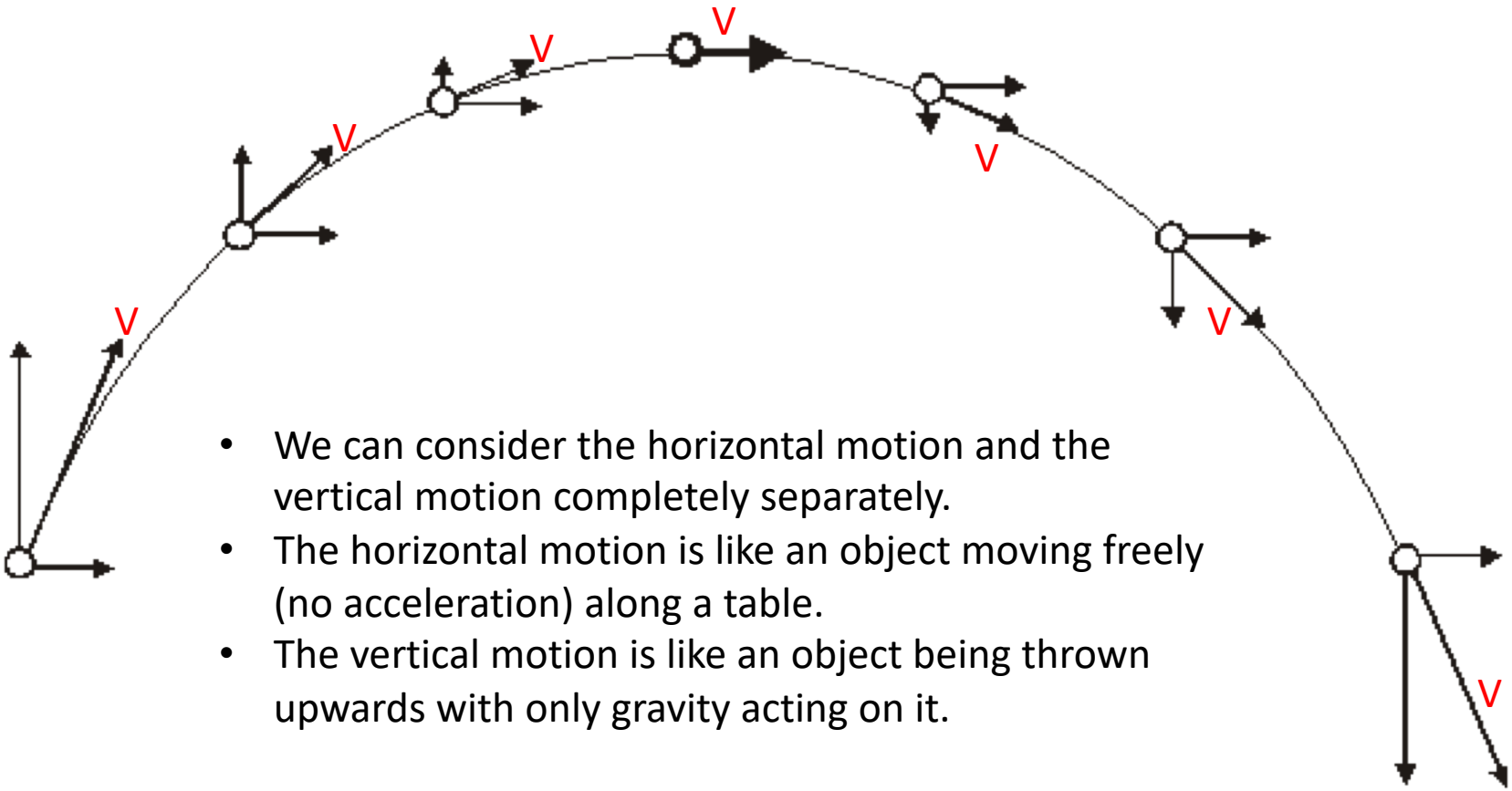

- We can consider the horizontal motion and the vertical motion completely separately.
- The horizontal motion is like an object moving freely (no acceleration) along a table.
- The vertical motion is like an object being thrown upwards with only gravity acting on it.

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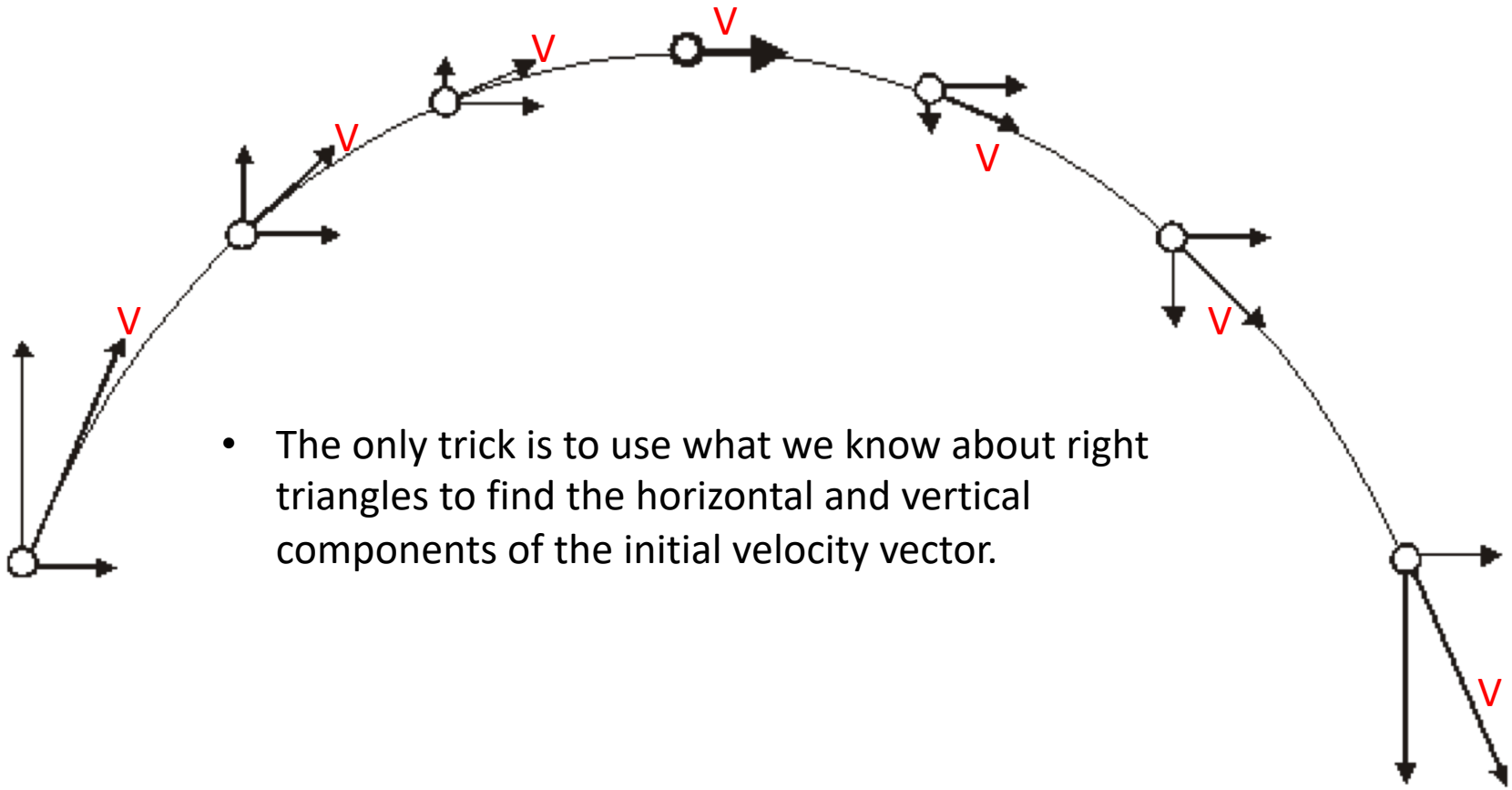

- The only trick is to use what we know about right triangles to find the horizontal and vertical components of the initial velocity vector.

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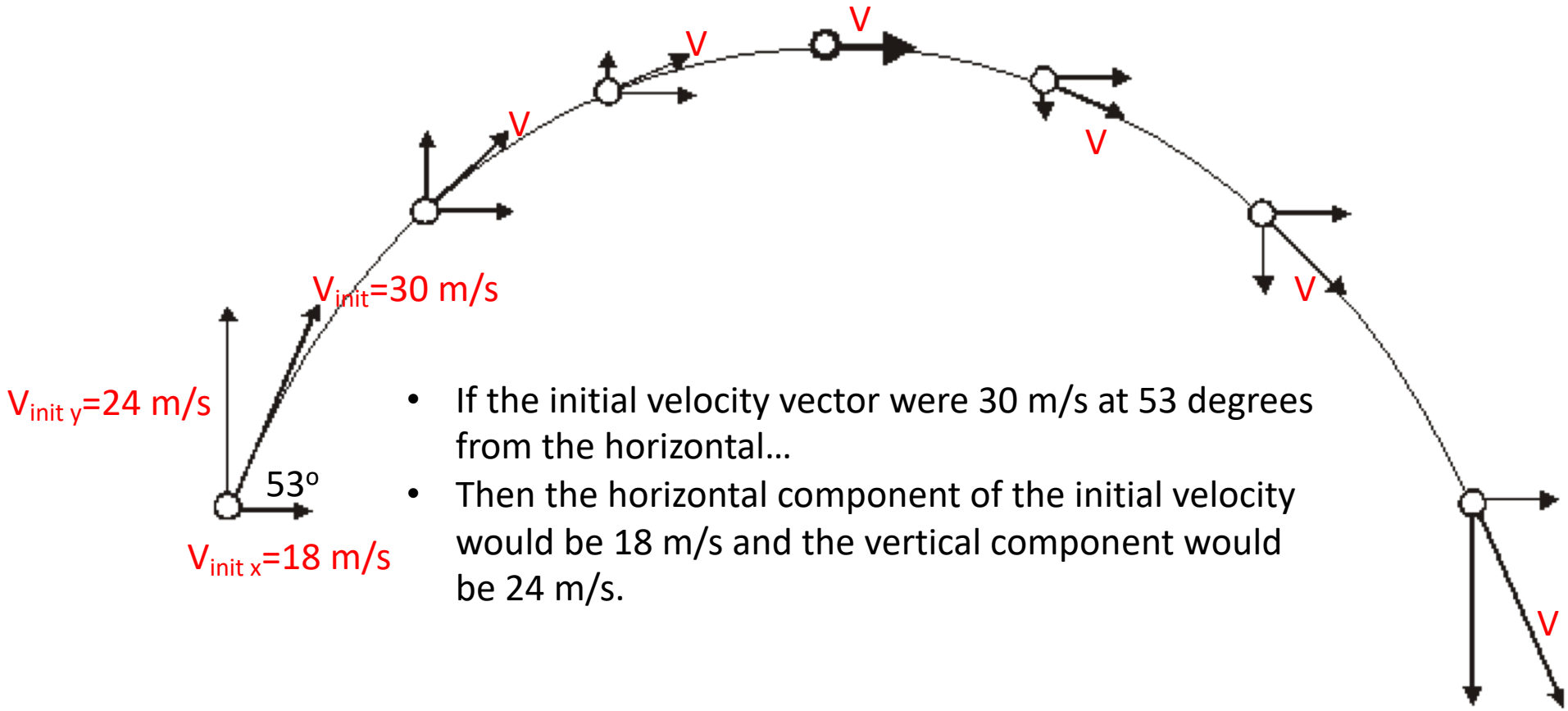

- If the initial velocity vector were 30 m/s at 53 degrees from the horizontal…
- Then the horizontal component of the initial velocity would be 18 m/s and the vertical component would be 24 m/s.

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- We could then calculate the horizontal motion as an object moving with a speed of 18 m/s and no acceleration.
- And we could calculate the vertical motion as an object thrown upwards with a speed of 24 m/s with only gravity acting on it.
- The combination of these two motions produces the 2-dimensional projectile motion.

Sketch and label the velocity components

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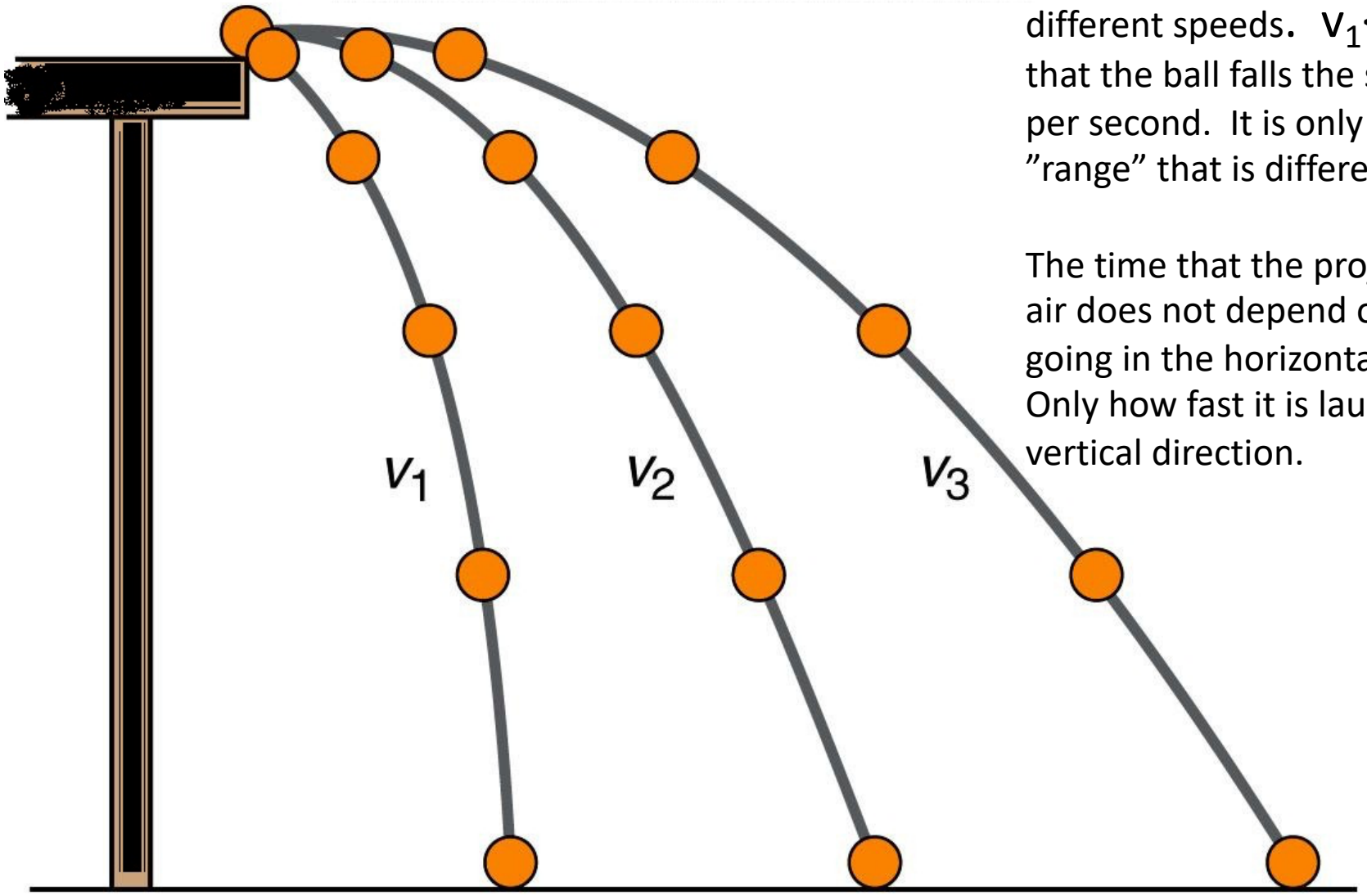

A ball is rolled off a table at three different speeds. $V_1<V_2<V_3$. Note that the ball falls the same distance per second. It is only the horizontal "range" that is different.

The time that the projectile is in the air does not depend on how fast it is going in the horizontal direction. Only how fast it is launched in the vertical direction.

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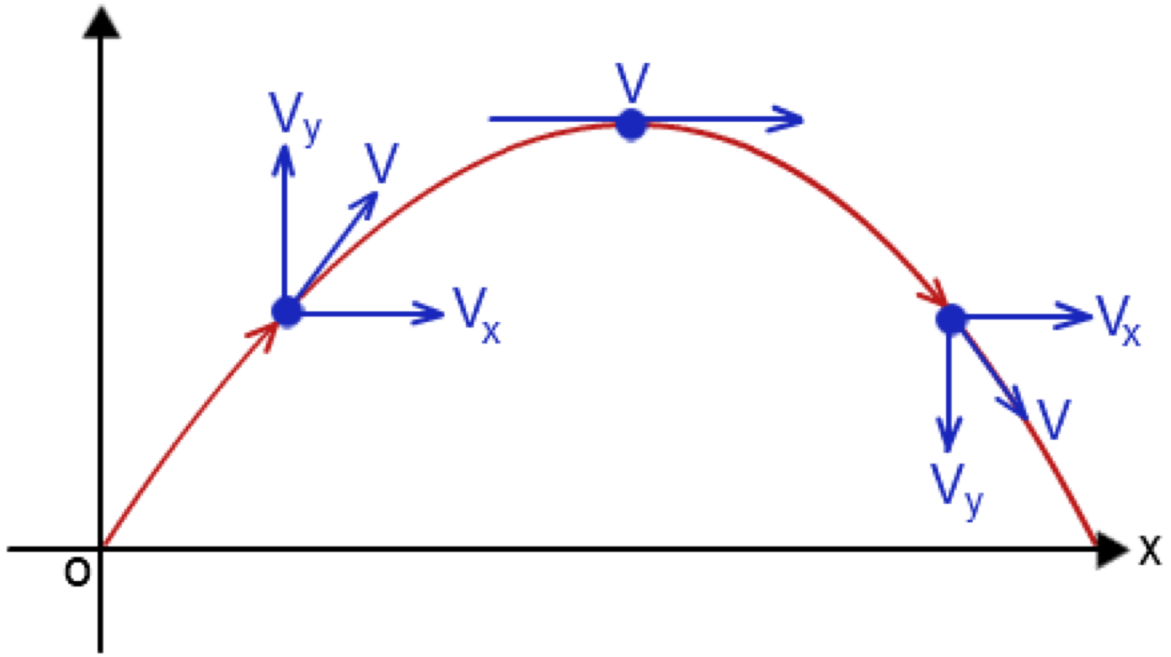
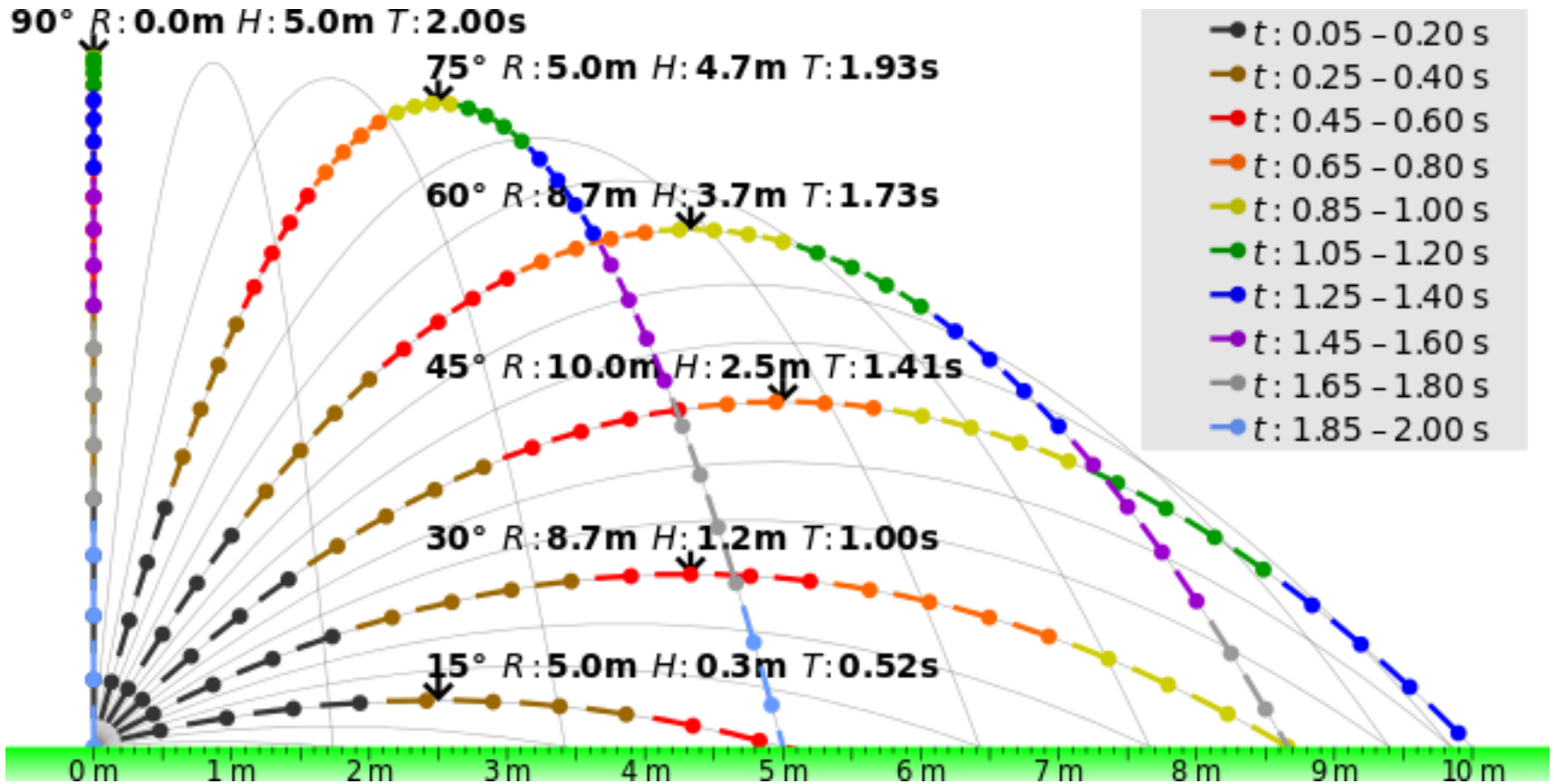


Questions

- A projectile is launched at an angle into the air. Neglecting air resistance, what is its vertical acceleration? 10 m/s^2 downward
  What is its horizontal acceleration? None
- At what point in its path does a projectile have minimum speed? At the top



Note that these projectiles reach different heights above the ground as well as travel different horizontal distances. But the same horizontal range can be obtained for two different projection ranges, those being for angles that add up to 90 degrees!

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Question: A boy on a 5 meter tall tower throws a ball horizontally and it reaches a distance of 20 m from the base of the tower. At what speed was the ball thrown?

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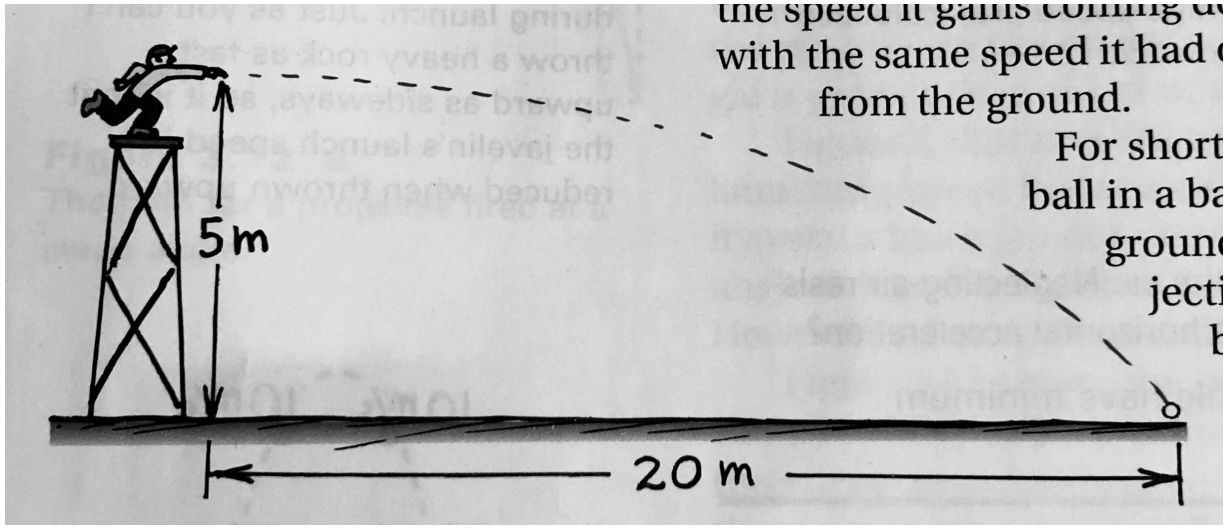
Satellites

Consider a ball thrown horizontally from the top of a tower. If gravity did not act on the ball, the ball's path would continue to be horizontal. One second after the ball is thrown it has fallen 5 meters below the horizontal. If the ball is thrown twice as fast, it will go twice as far, but still fall 5 meters in the first second.



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Satellites

What if the ball were thrown so fast that its curved path matched the curve of the Earth's surface? We can say it "continually falls" around the Earth. It would then be an Earth satellite. It turns out that the speed necessary to make an object orbit close to the Earth is 8 km/s.