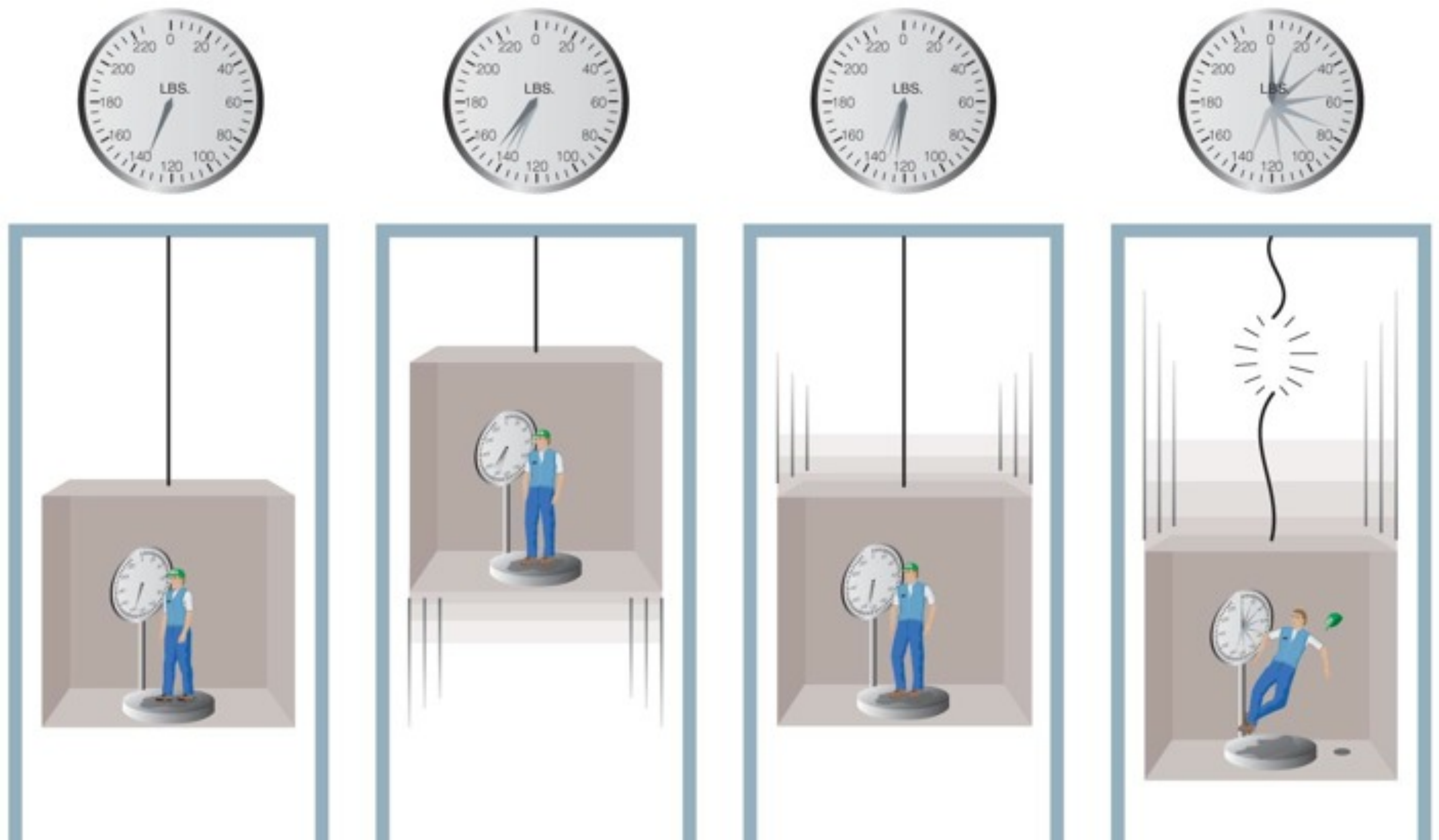

Moving
through
SPACE!
ASTR 1120
Adam Ginsburg & Devin Silvia
July 8th, 2010

Learning Goals

- Define some terms: mass, momentum, angular momentum, conservation, orbit
- Understand orbits and gravity
- Understand how Doppler Shift can be used to measure motions

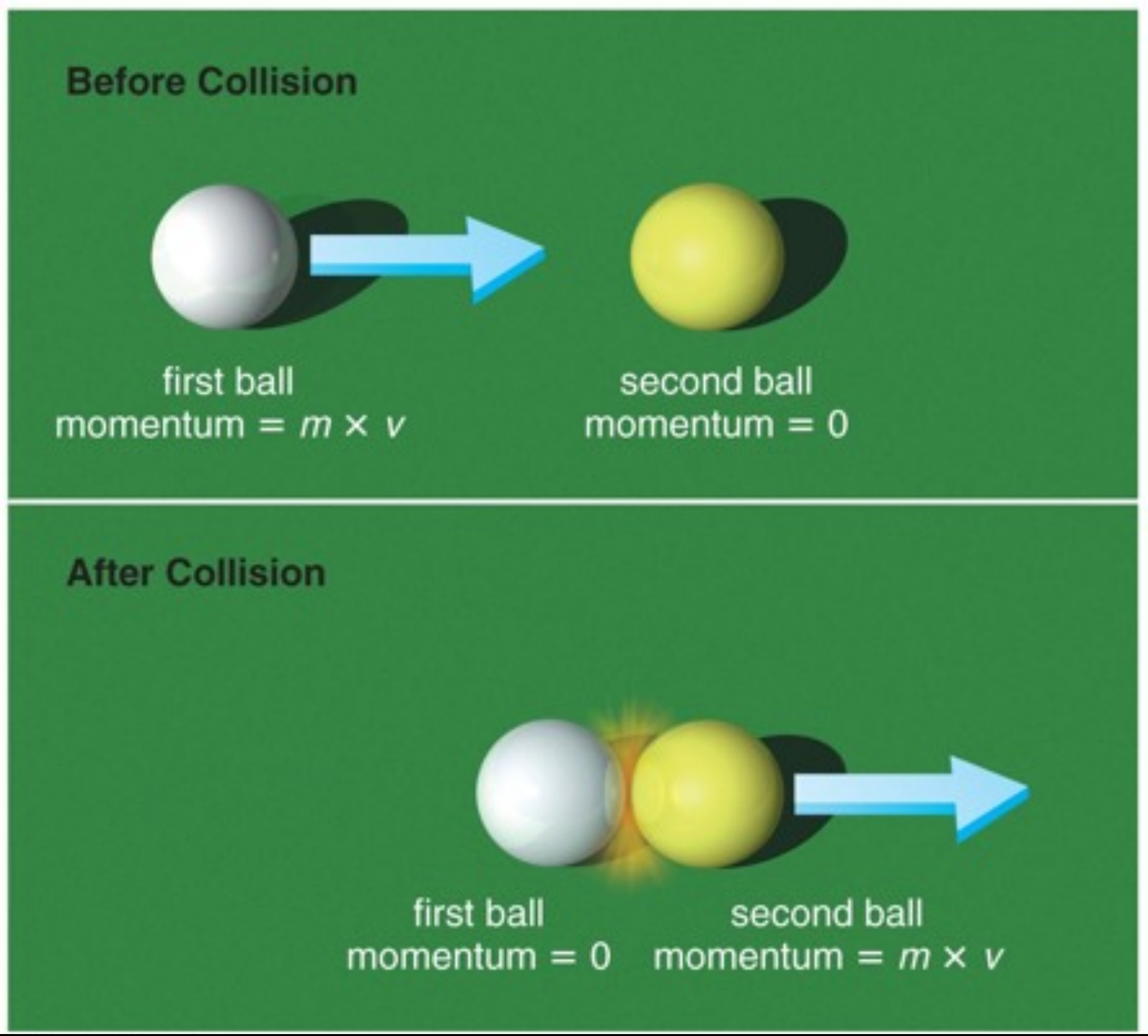
Mass and Weight

- **Mass** – the amount of matter in an object
- **Weight** – the *force* that acts upon an object



Momentum

- Momentum = mass x velocity
  - An object moving in one direction keeps moving unless acted on by some force



Momentum

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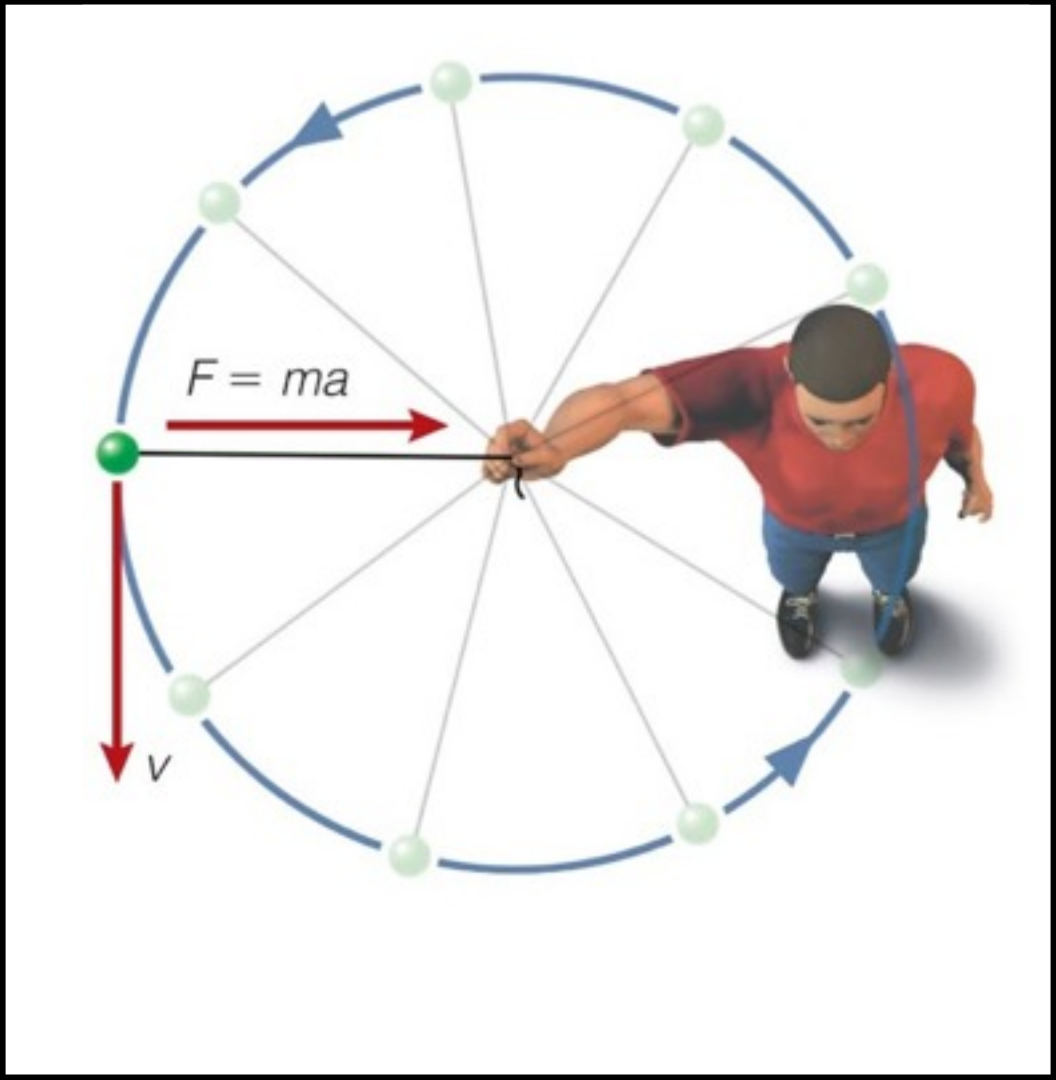
The string pulls the ball inward, so it is constantly changing direction



Momentum

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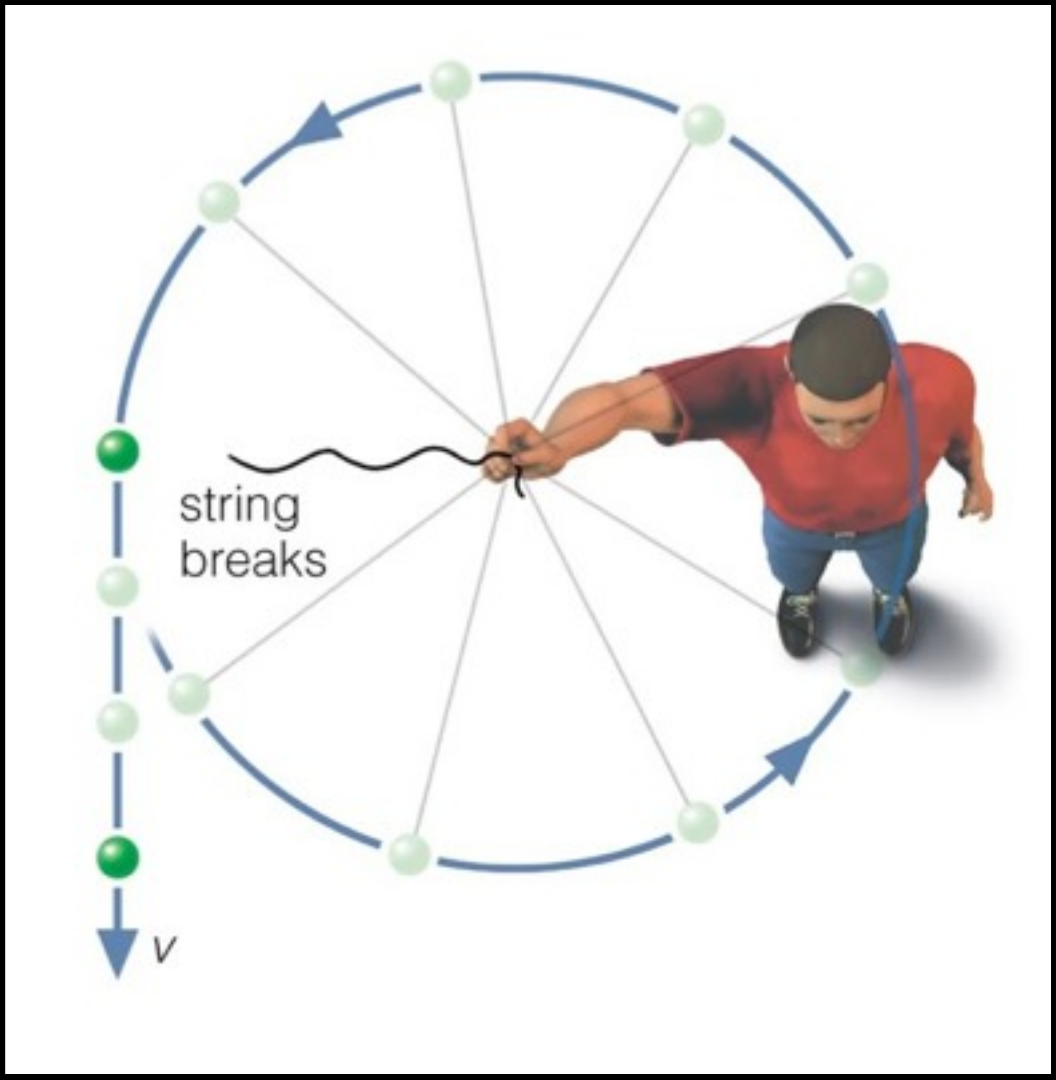
    - An object moving in one direction keeps moving unless acted on by some force

Without the string pulling it, the ball will follow a straight path



Conservation of Momentum

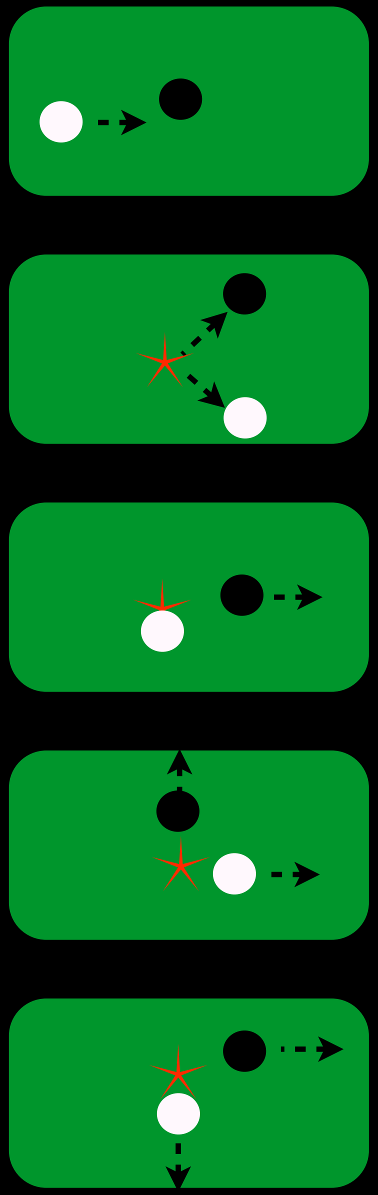
- What happens if a pool ball hits another pool ball at a glancing angle?

A) Both move forward and to the side

B) One stops, the other goes forward

C) The first pool ball continues straight, but the second starts going sideways

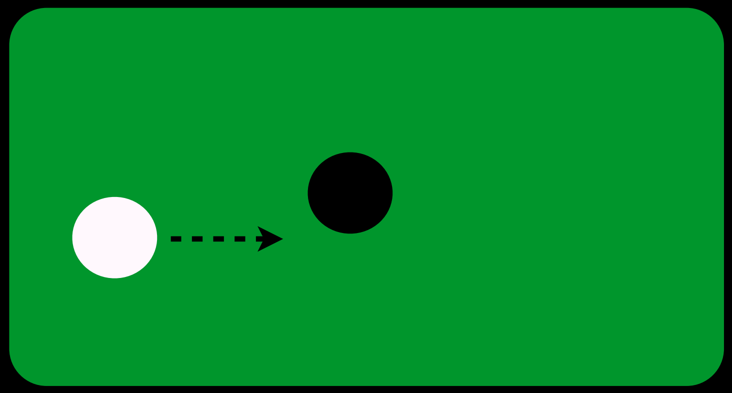
D) The first pool ball goes side ways, but the second goes straight

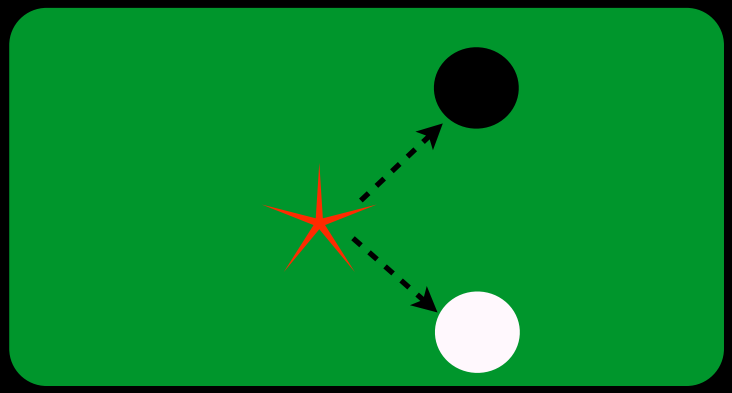


Conservation of Momentum

- What happens if a pool ball hits another pool ball at a glancing angle?

A) Both move forward and to the side

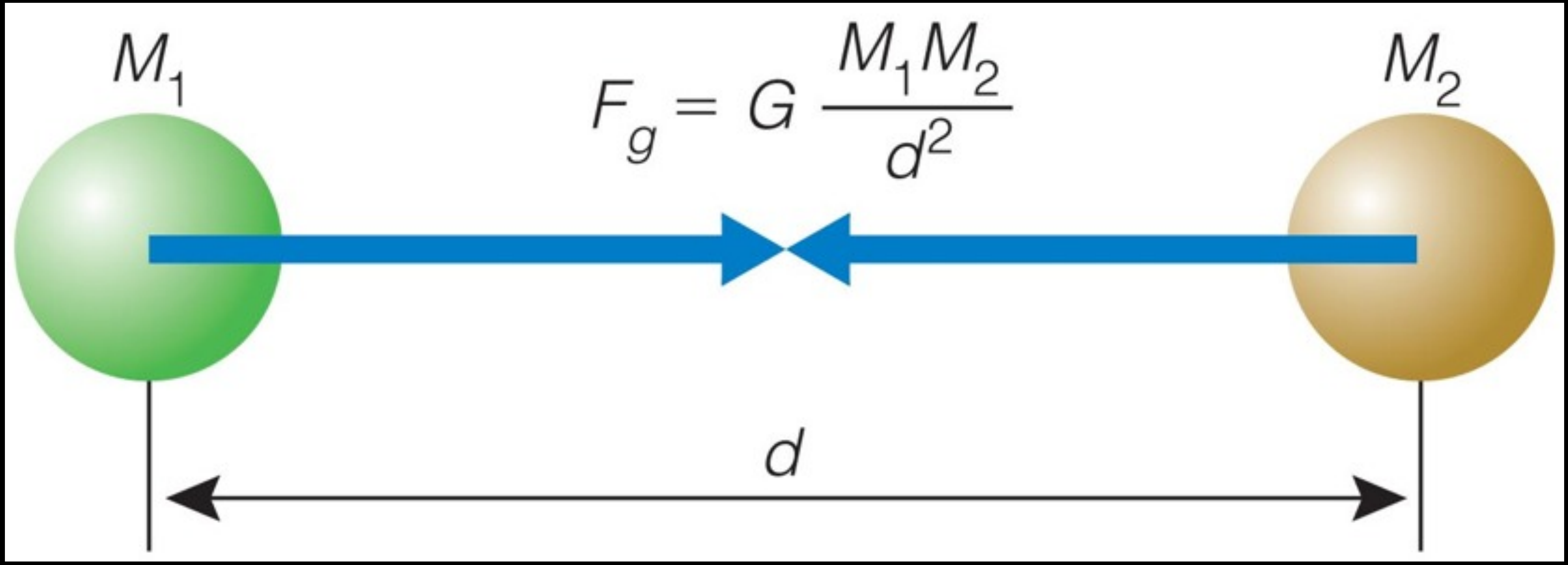




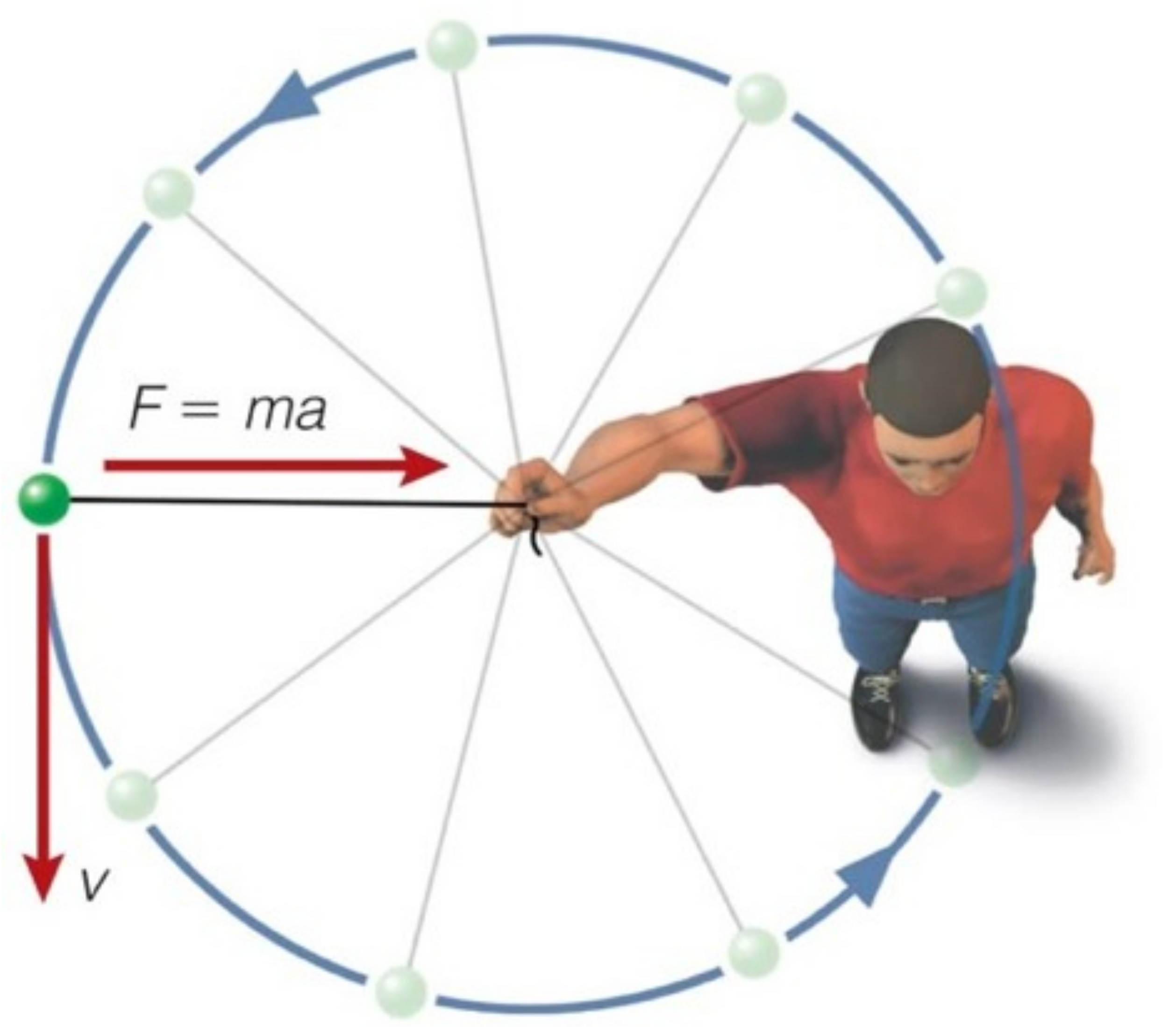
Momentum is conserved in both directions: the mass moving forward increases, so the velocity drops. The total side-to-side velocity is zero.

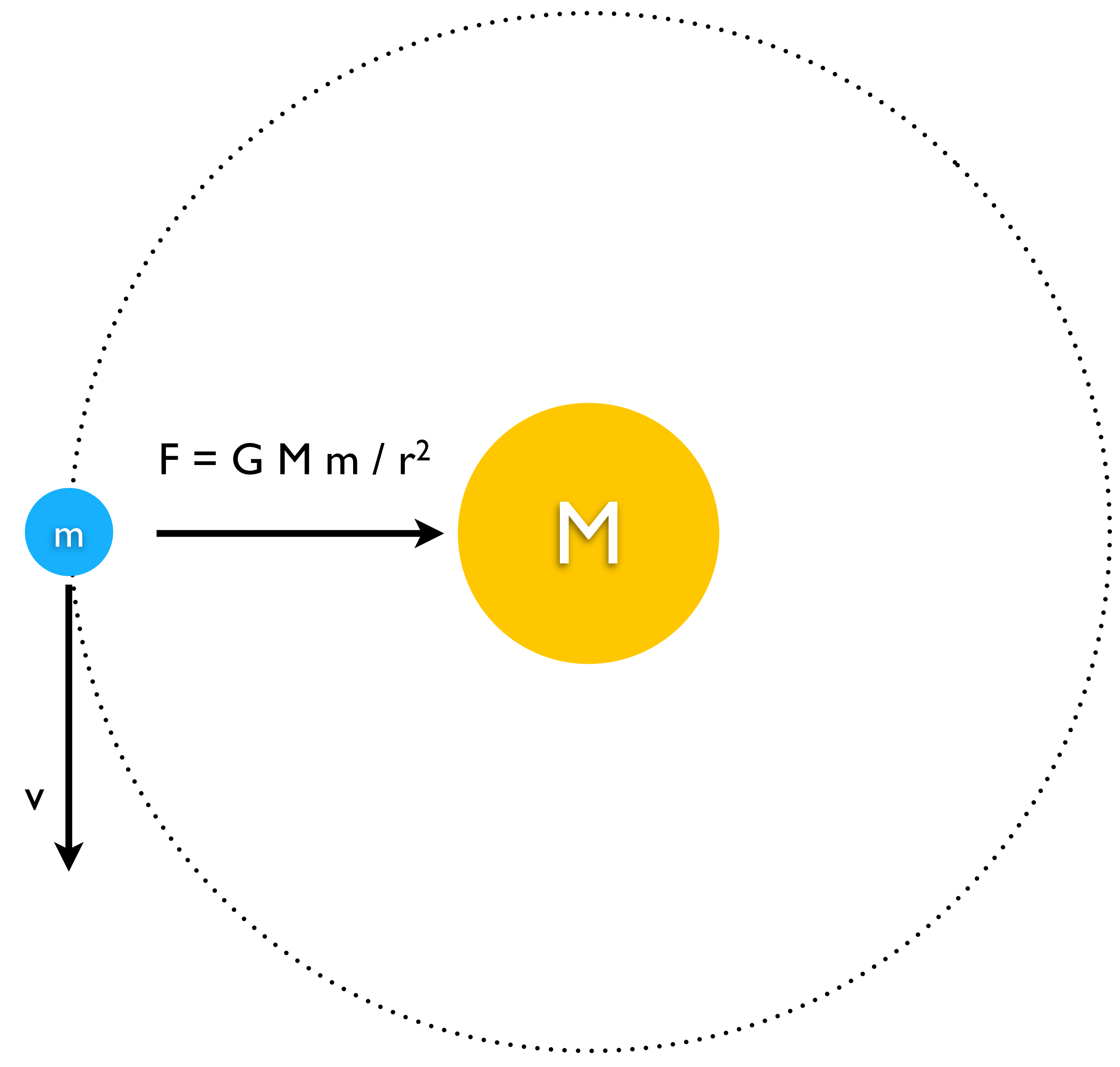
Gravity

- Every mass attracts every other mass
- It is the most important force in astronomy because it acts on large scales and is always attractive



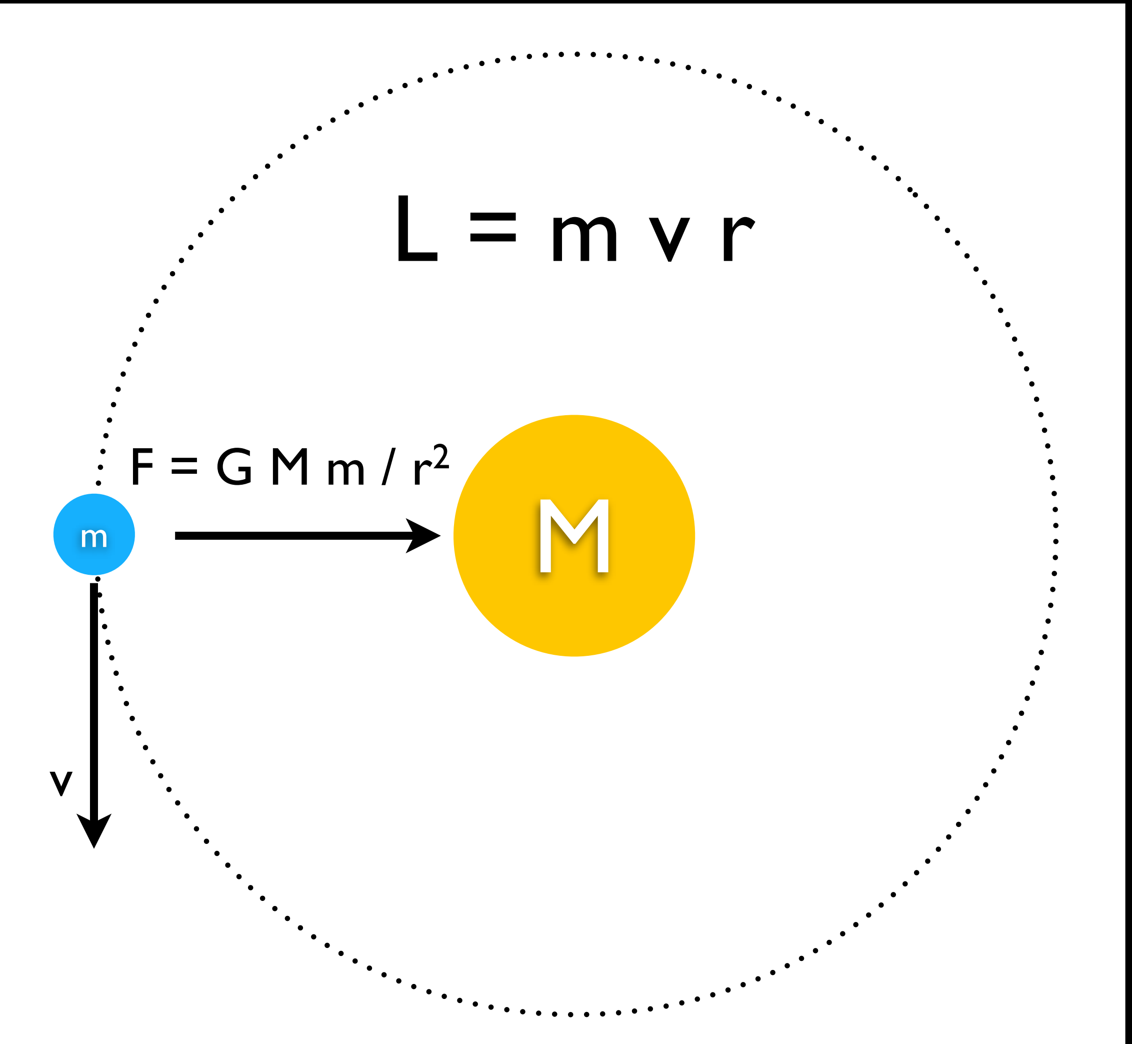
Gravity acts like the string





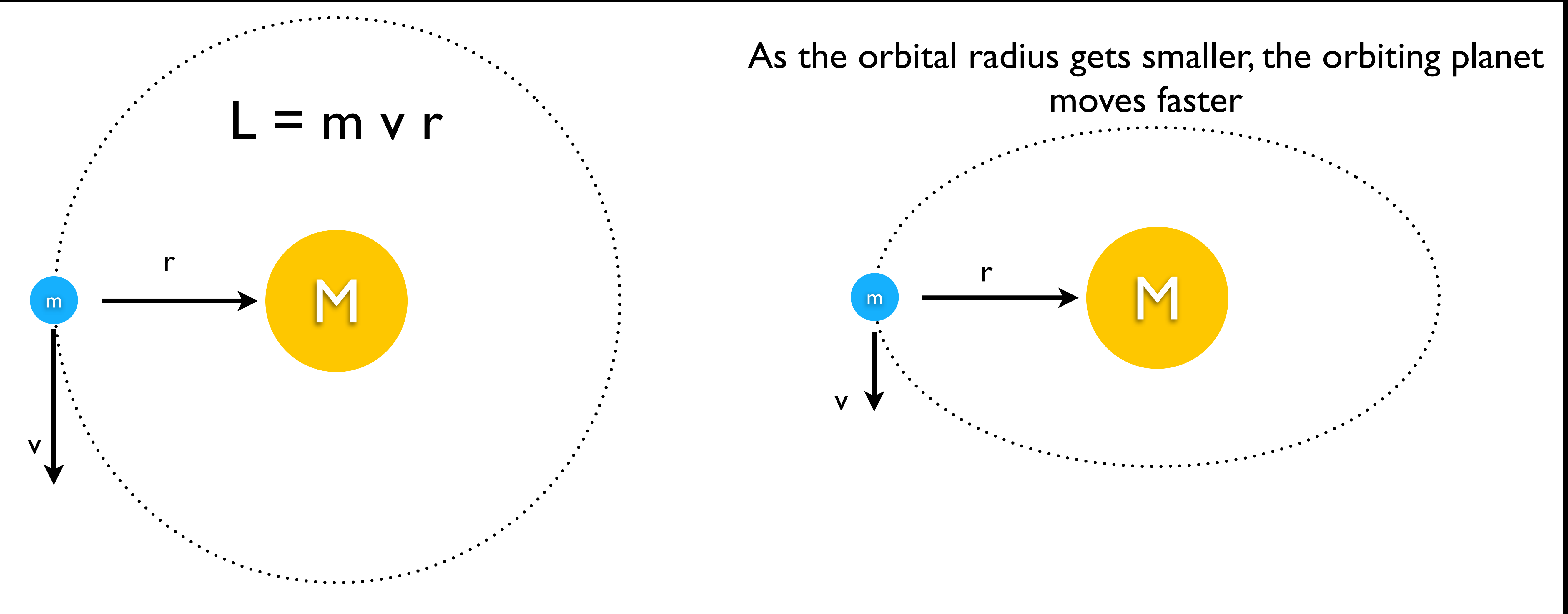
Angular Momentum

- Angular momentum = mass x velocity x radius
    - conserved in rotating systems (doesn't change unless acted on by an outside force)



Angular Momentum: Orbits

- Angular momentum = mass x velocity x radius is conserved in rotating systems including elliptical orbits



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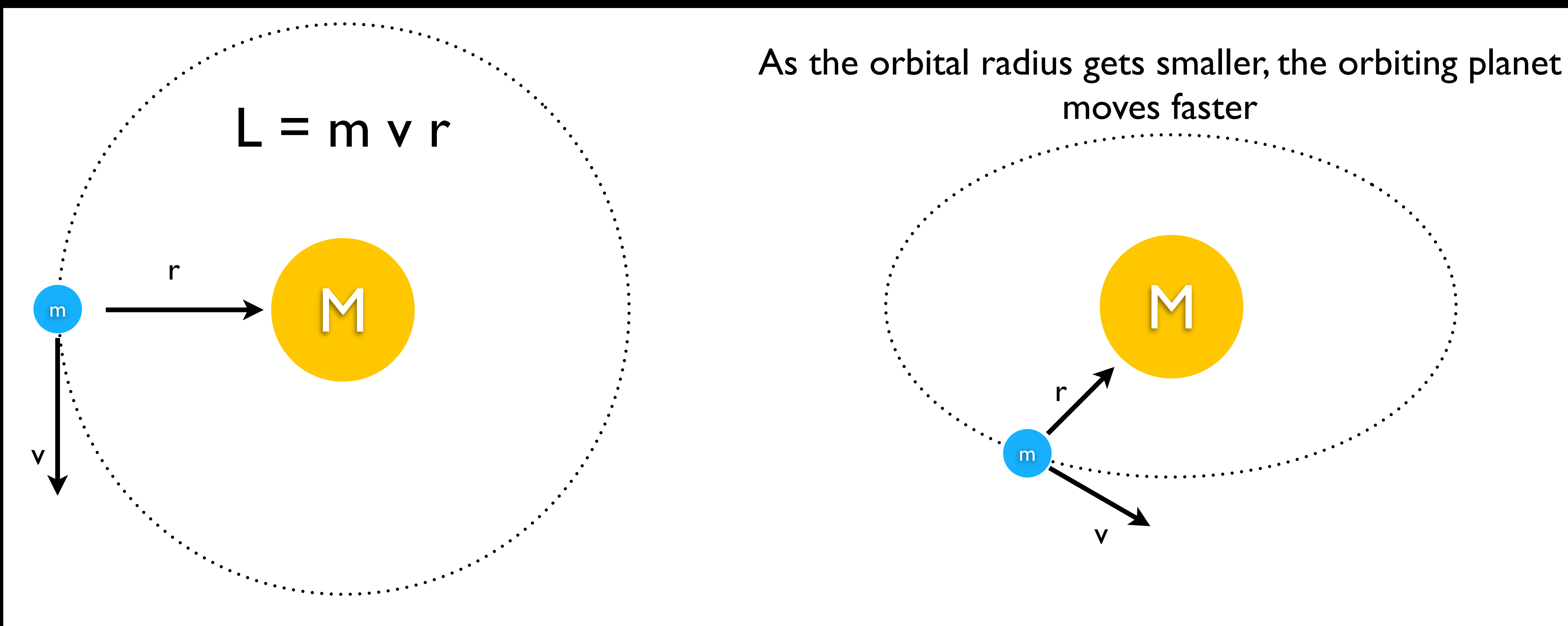

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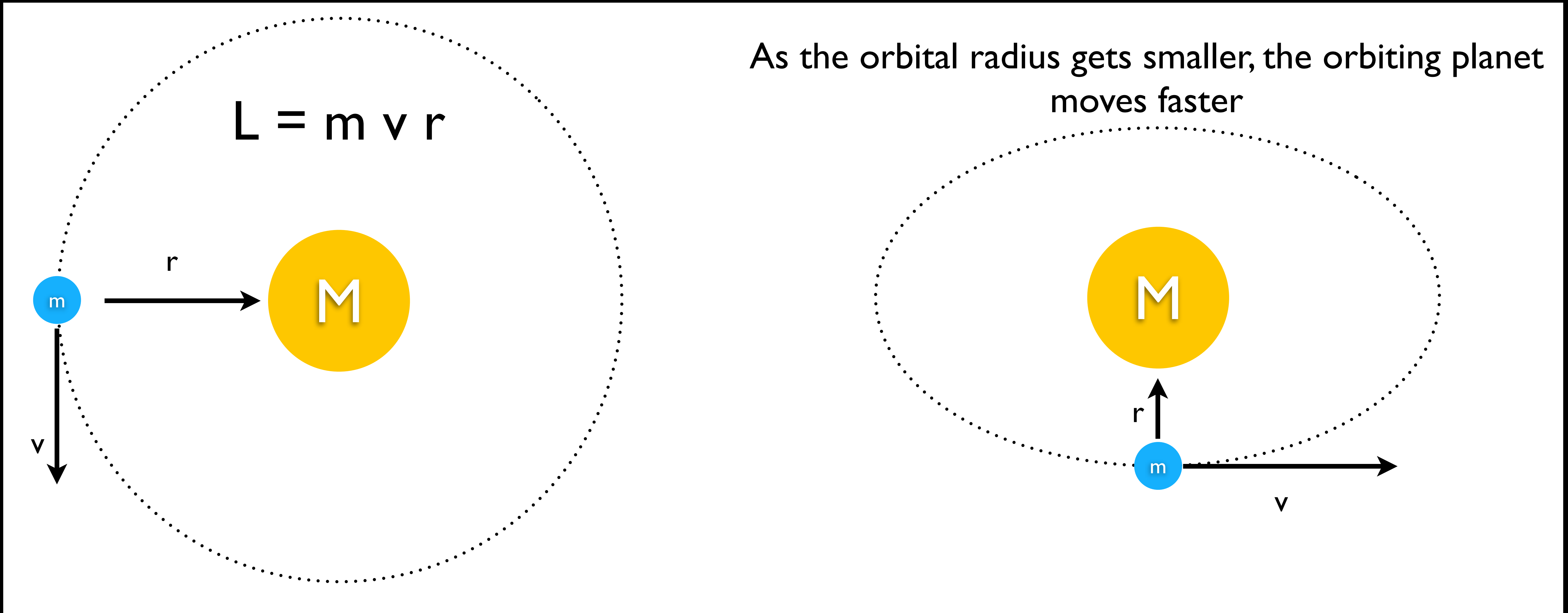
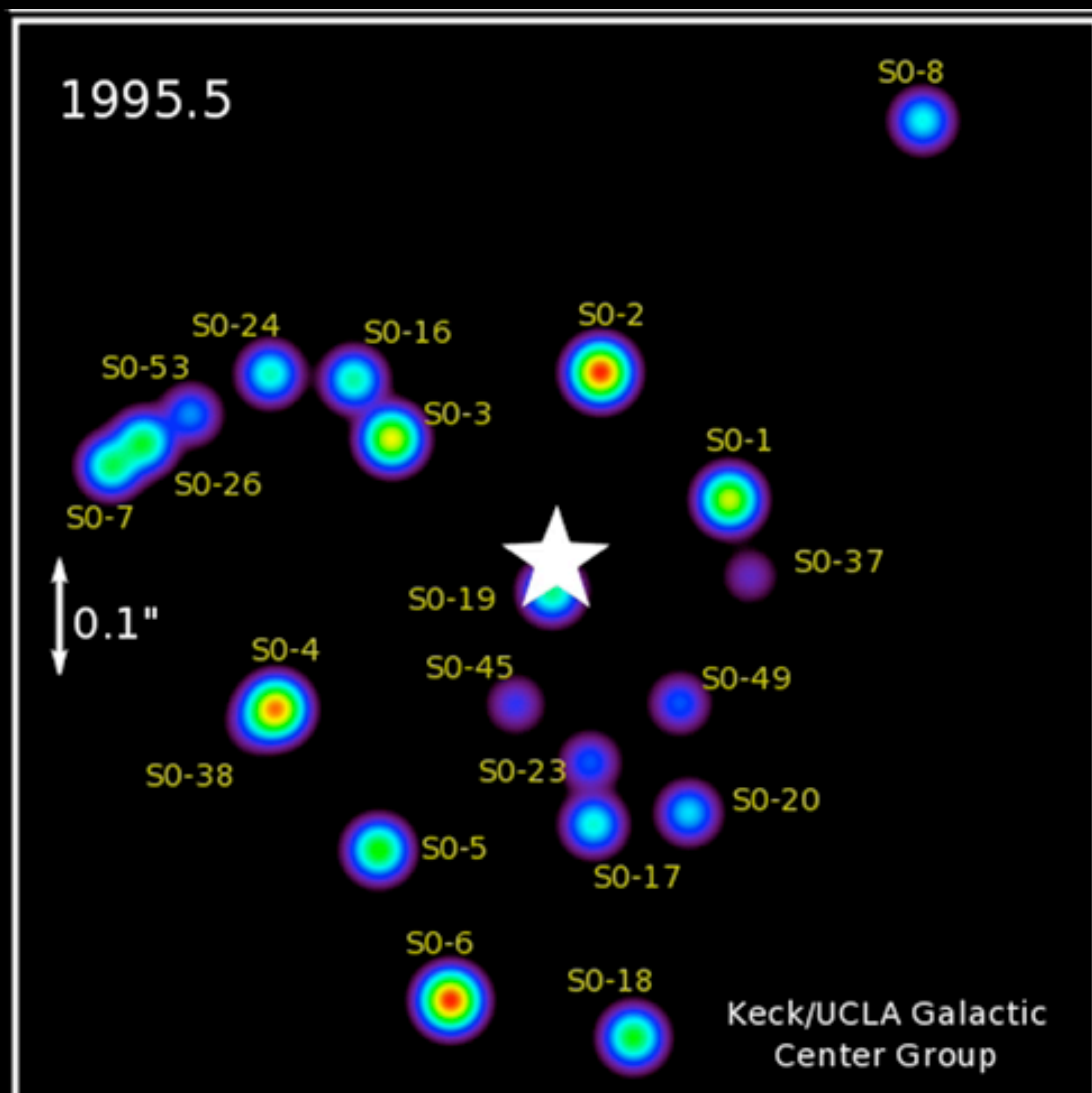


Example: Stars orbiting a Black Hole



Angular momentum is conserved

- Demo: Spinning platform
  - Friction will eventually stop the spin
  - Planets and stars orbiting stars don’t experience friction, but gas does

Clicker Question: Momentum & Gravity

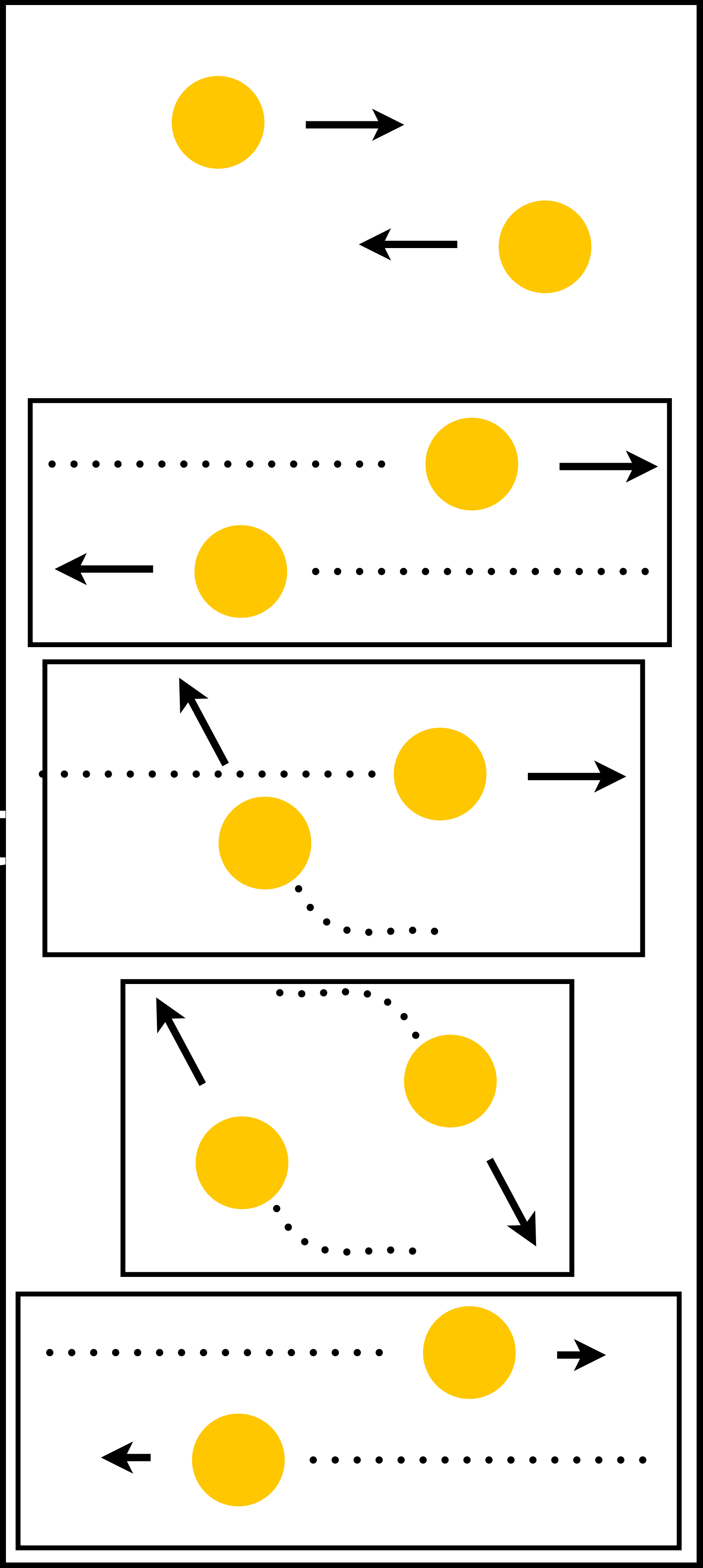
- If two identical stars are approaching each other closely, but not closely enough to hit, what will happen to their paths?

A) They will keep going straight

B) One of them will curve away, but the other will go straight along

C) Both stars' paths will curve

D) They will keep going straight, but slower



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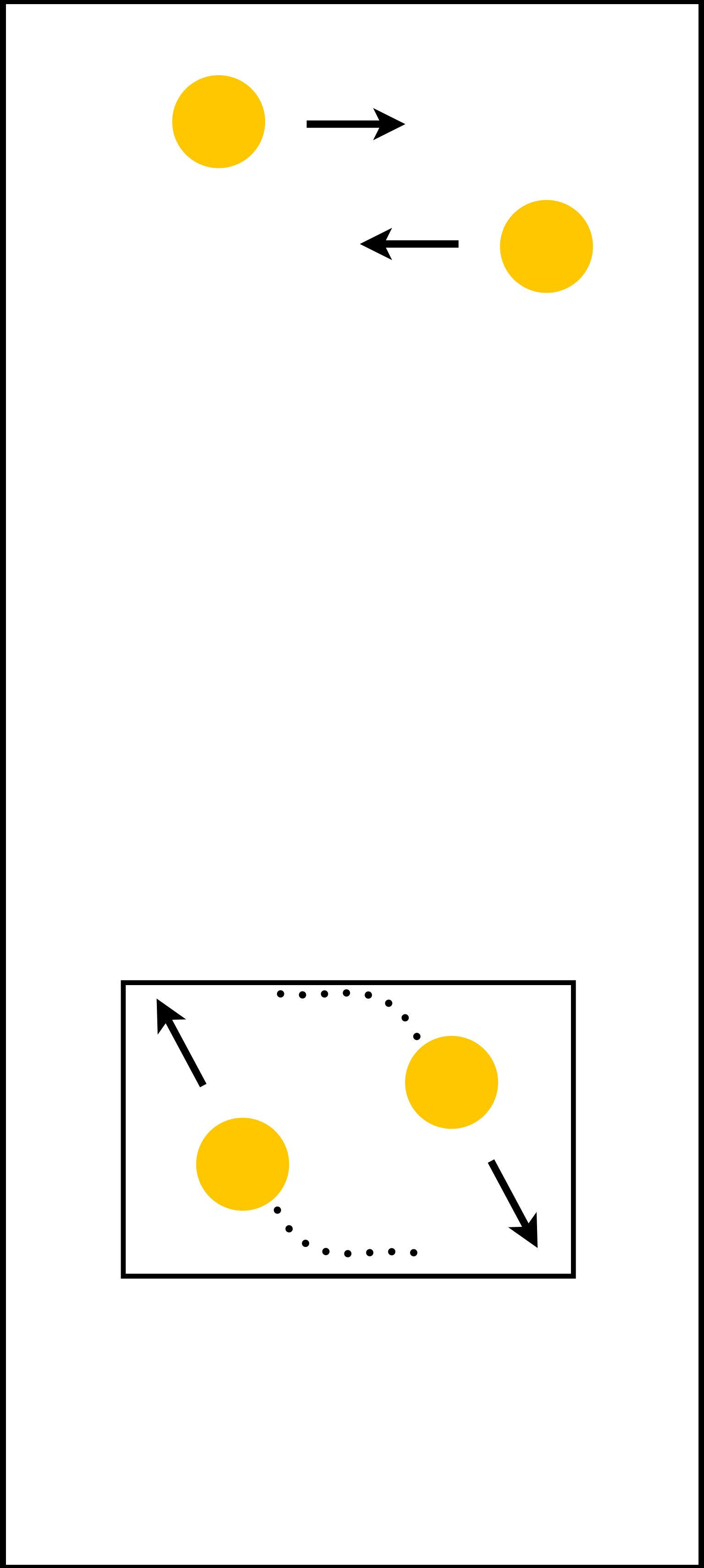
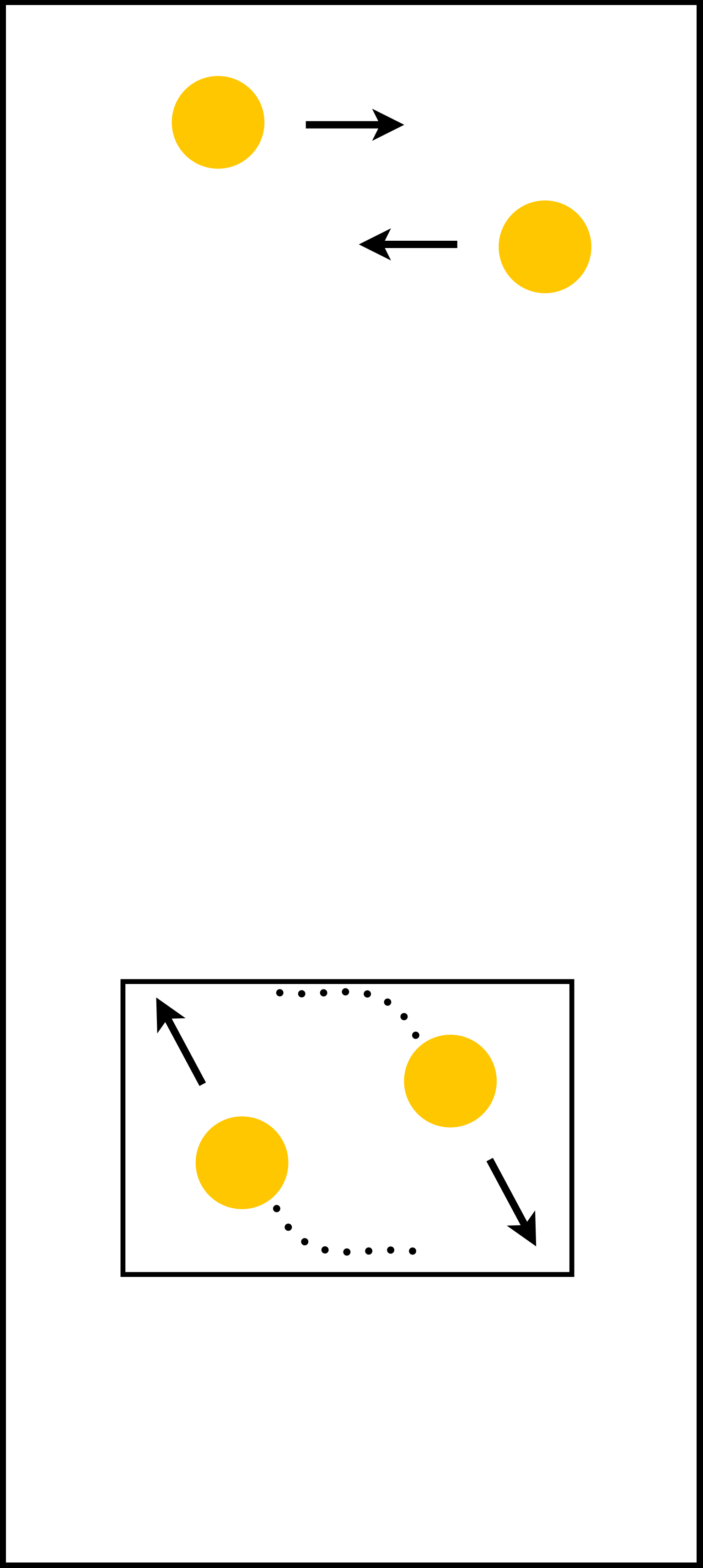


C) Both stars’ paths will curve

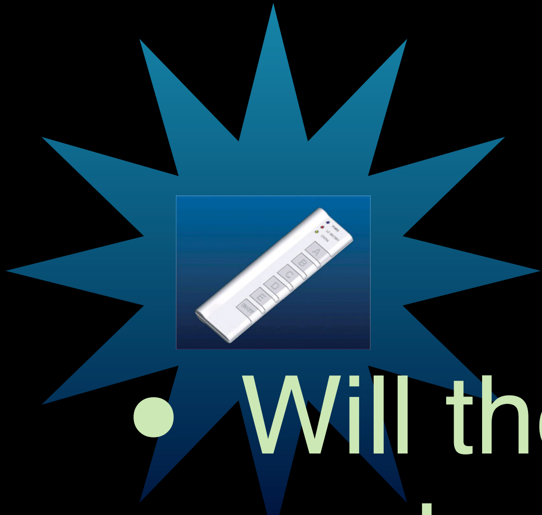
Clicker Question: Momentum & Gravity



- If two identical stars are approaching each other closely, but not closely enough to hit, what will happen to their paths?

C) Both stars' paths will curve

Gravity acts on both stars equally: All objects with mass gravitationally attract all others



Clicker Question: Momentum & Gravity

- Will they go into orbit around each other?

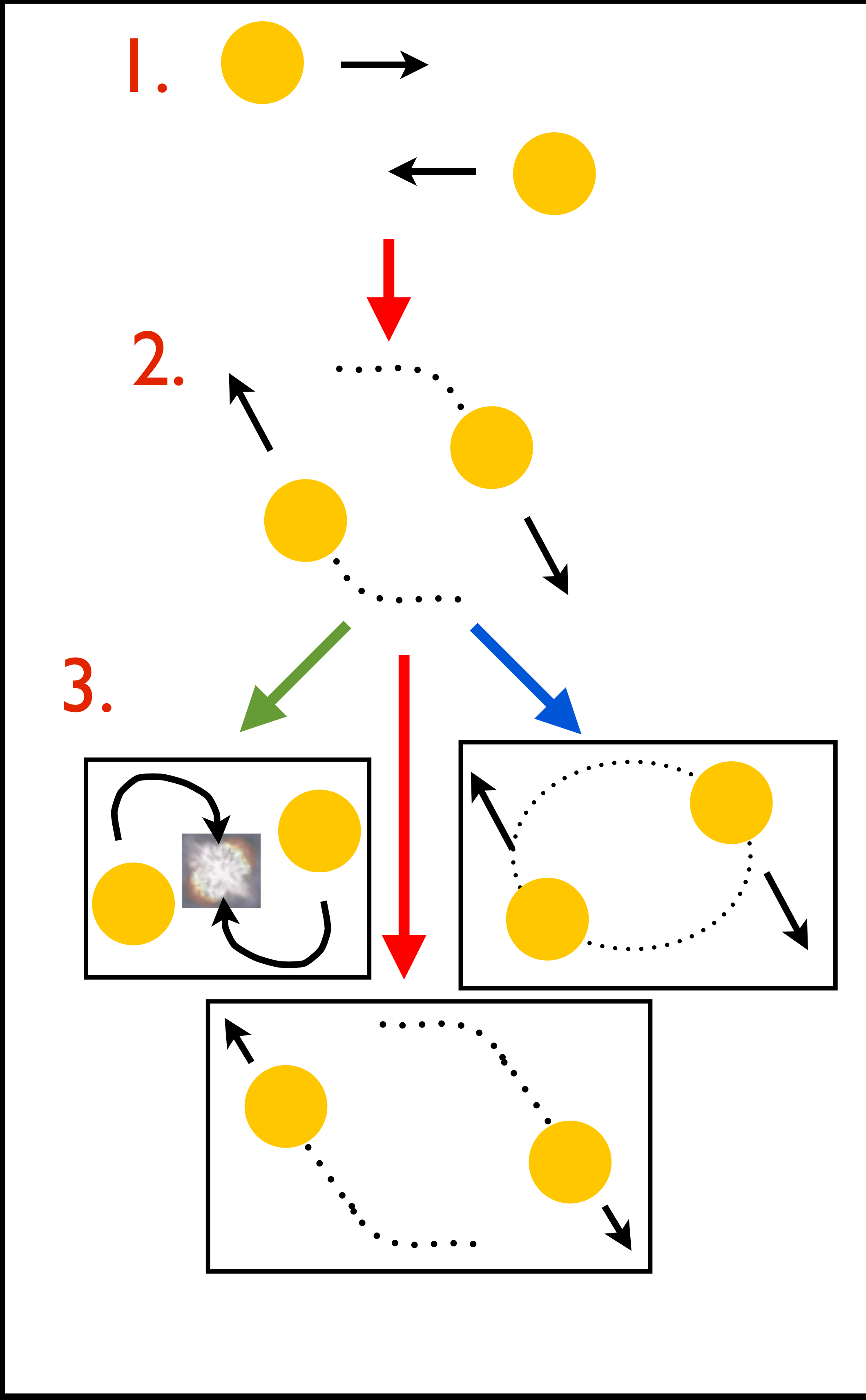
A) No, they'll go past each other

B) No, they'll collide

C) Maybe, it depends only on their mass and velocity

D) Maybe, it depends on their mass, velocity, and closest distance

E) Yes, definitely



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- Will they go into orbit around each other?

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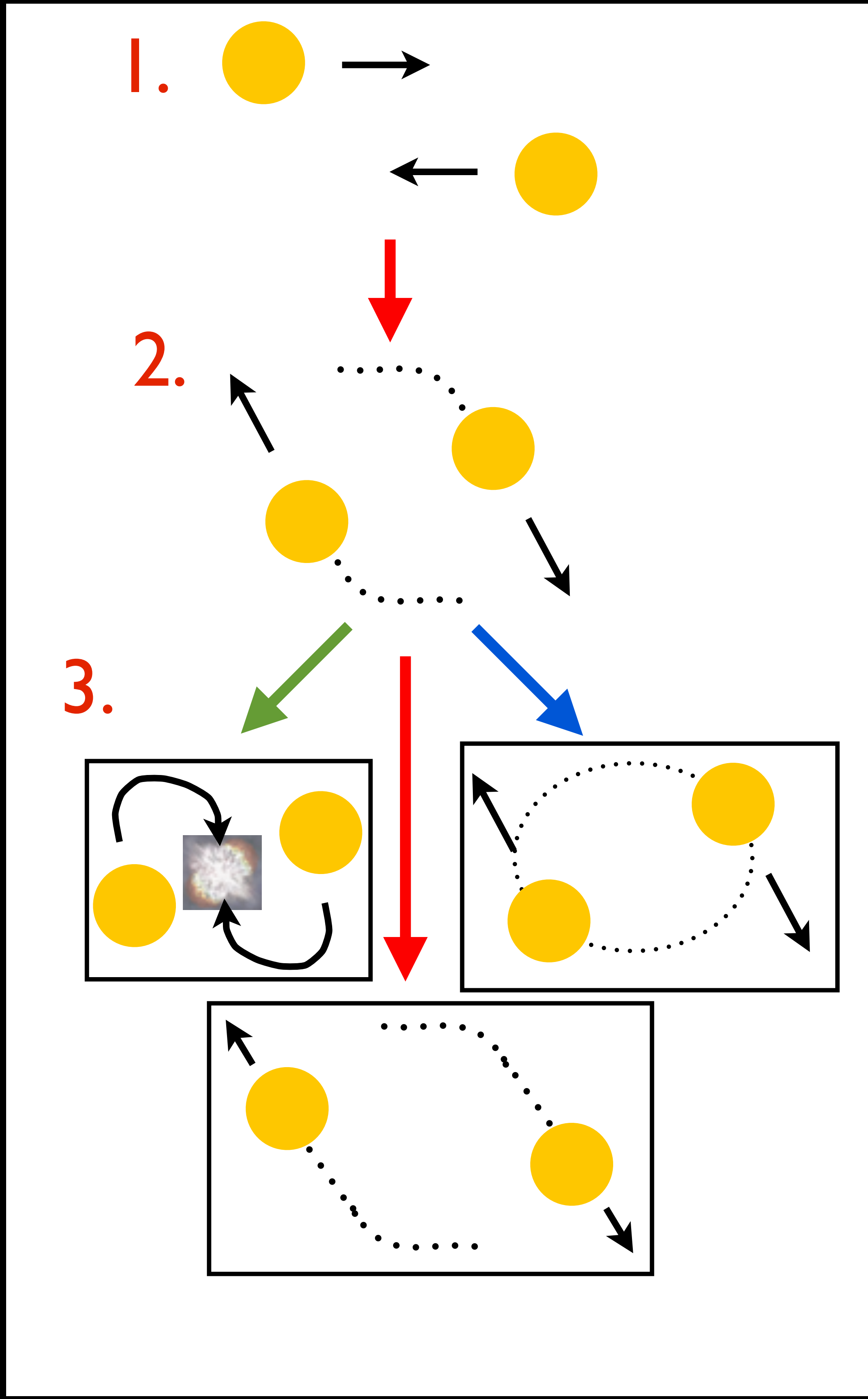


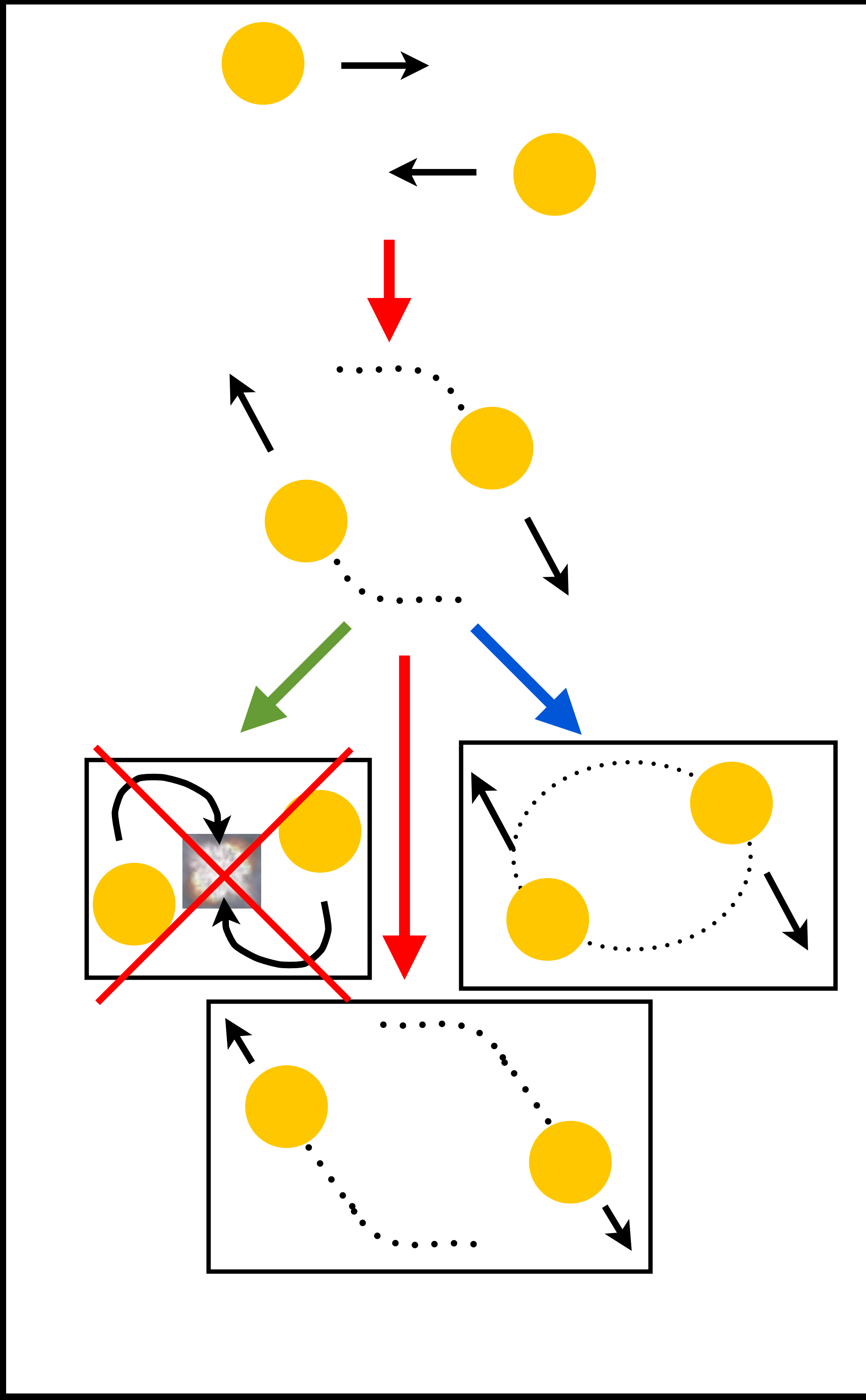
Clicker Question: Momentum & Gravity

- Will they go into orbit around each other?

D) Maybe, it depends on their mass, velocity, and closest distance

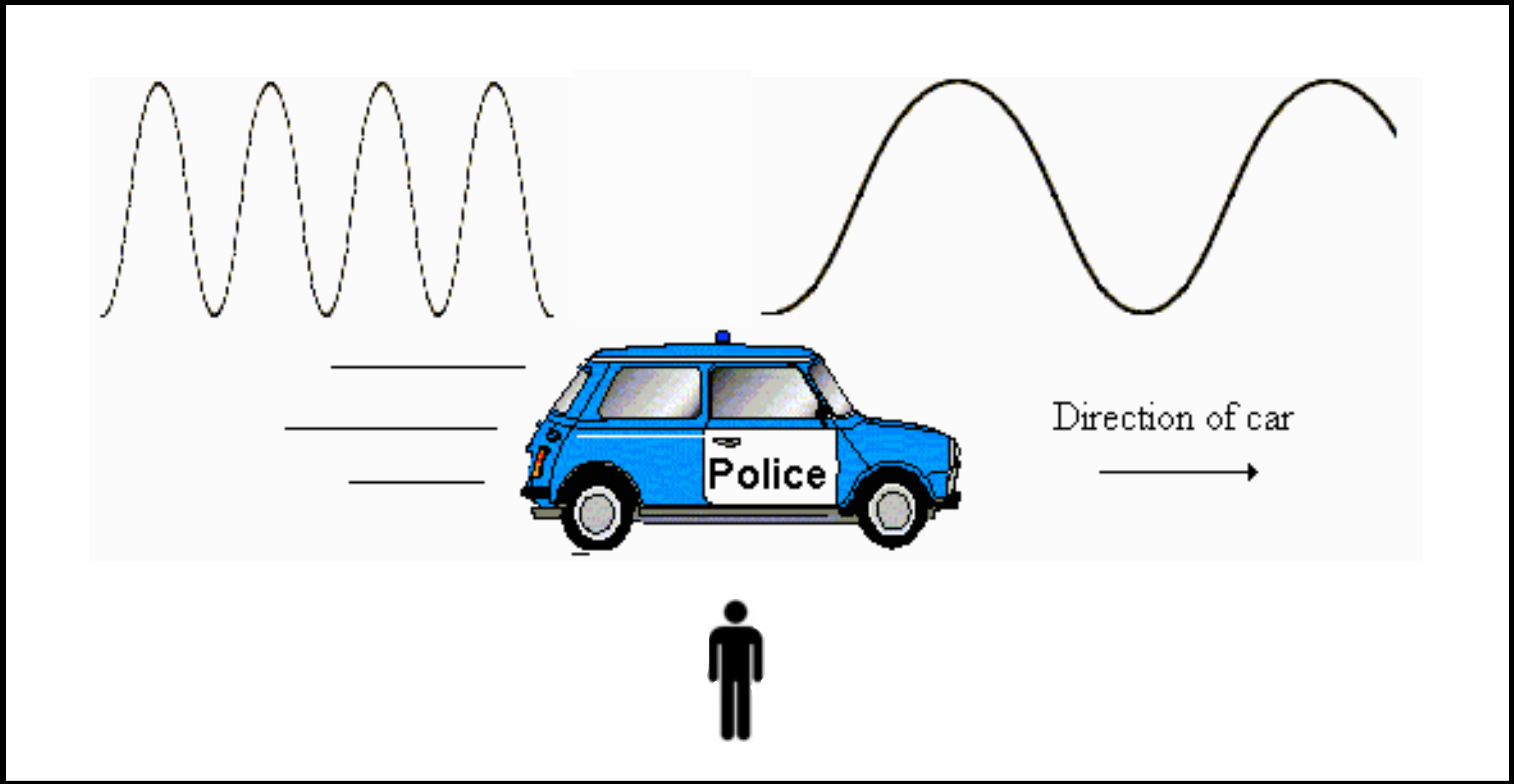
As long as there is no friction and the stars don't hit, angular momentum is conserved

If the masses are large enough, and distance and velocity are small enough, the stars will begin to orbit each other



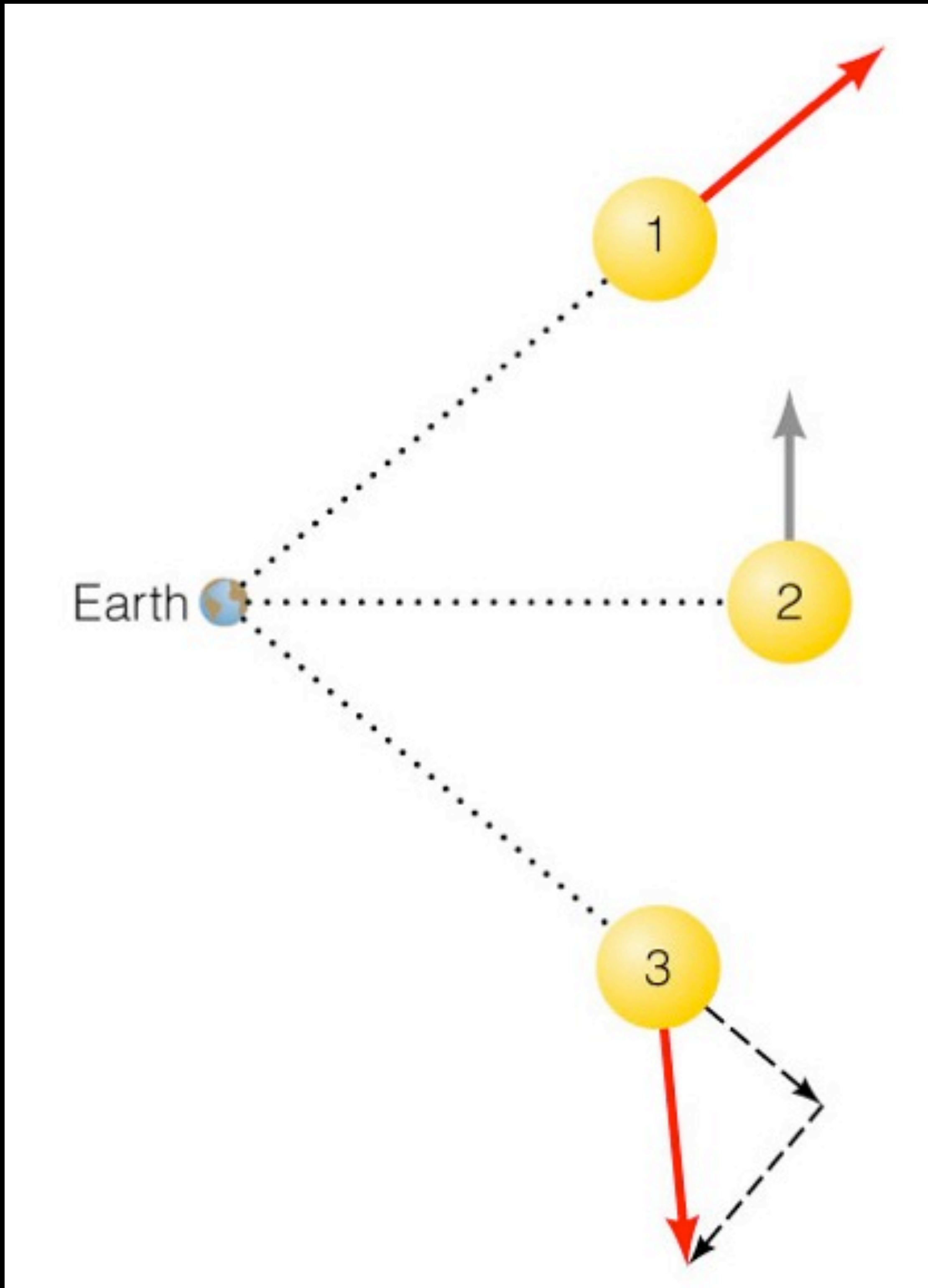
PART 2: Doppler Shift

- How do we detect motion?
  - When objects are moving, the wavelength of light they emit (or reflect) changes
  - The same effect occurs with sound

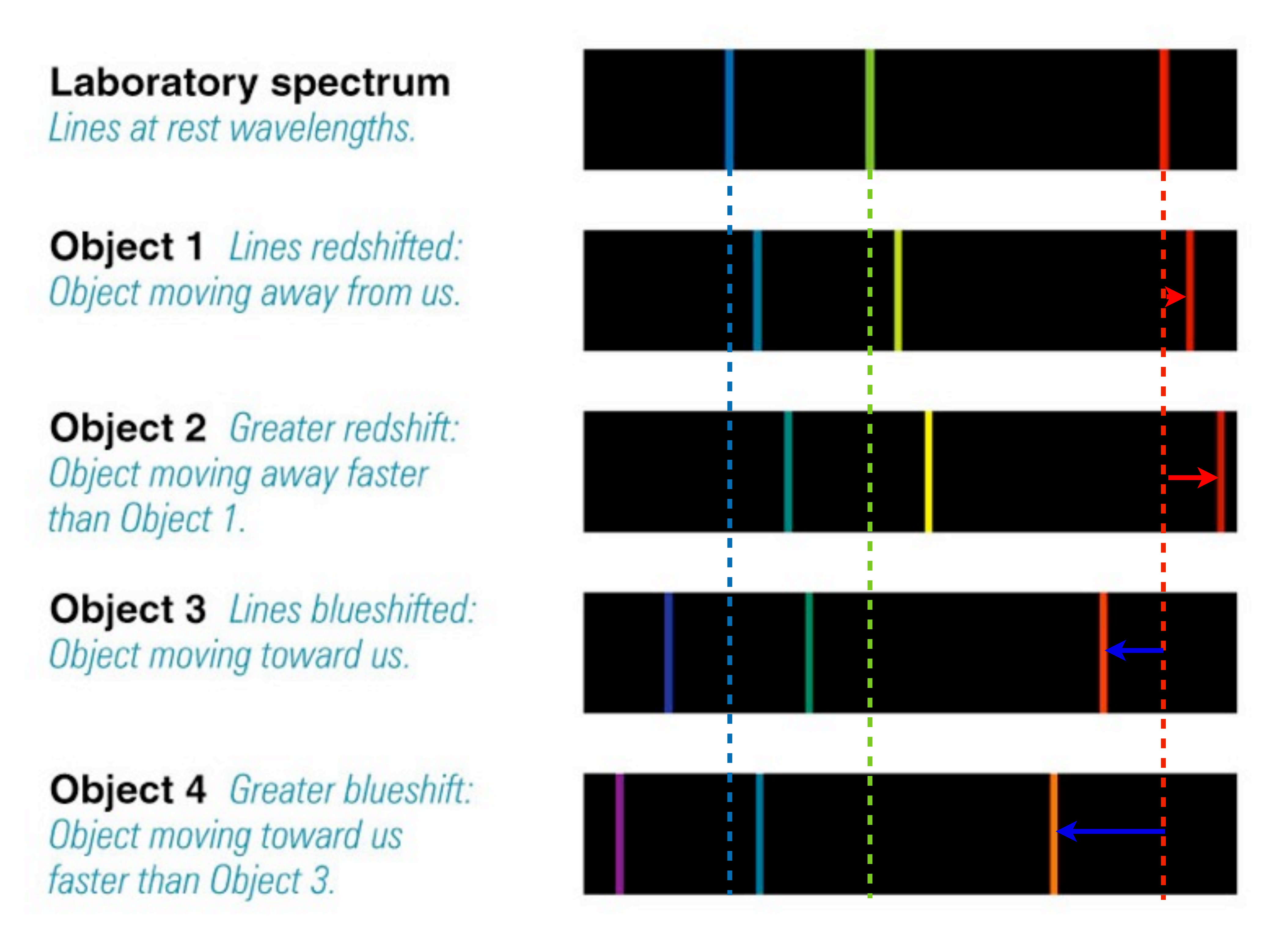


Line-of-sight

- Doppler shift only occurs when an object is moving towards or away from the observer
- Side-to-side motion does not create doppler shift

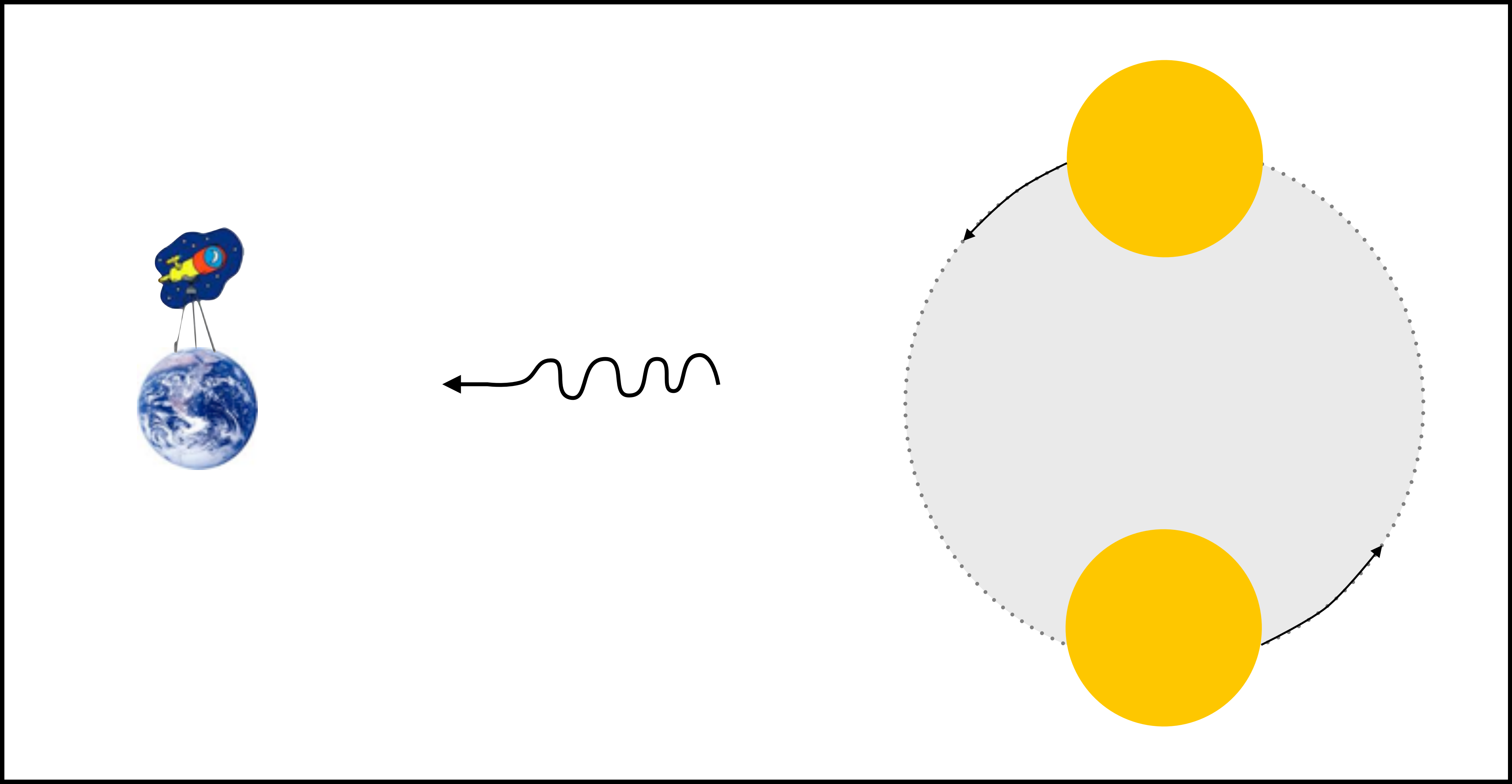


Emission Lines & Doppler Shift



Example: Spectroscopic Binary

- As the stars orbit each other, their line frequencies will shift



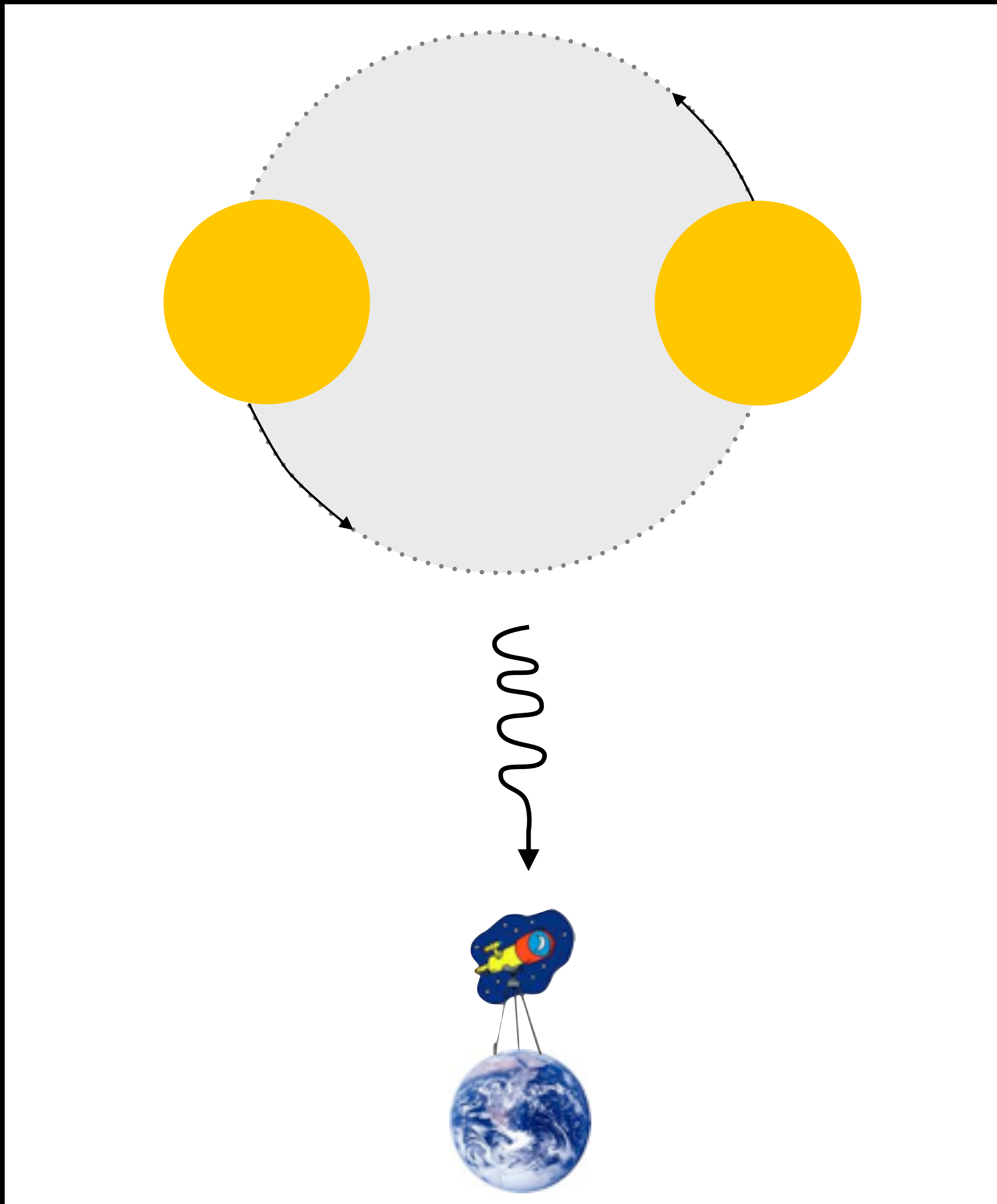
Spectrosopic Binary

- Which best describes the spectrum of the pictured system?

A) Two separate narrow lines, one red, one blue

B) One big, smeared line

C) One narrow line



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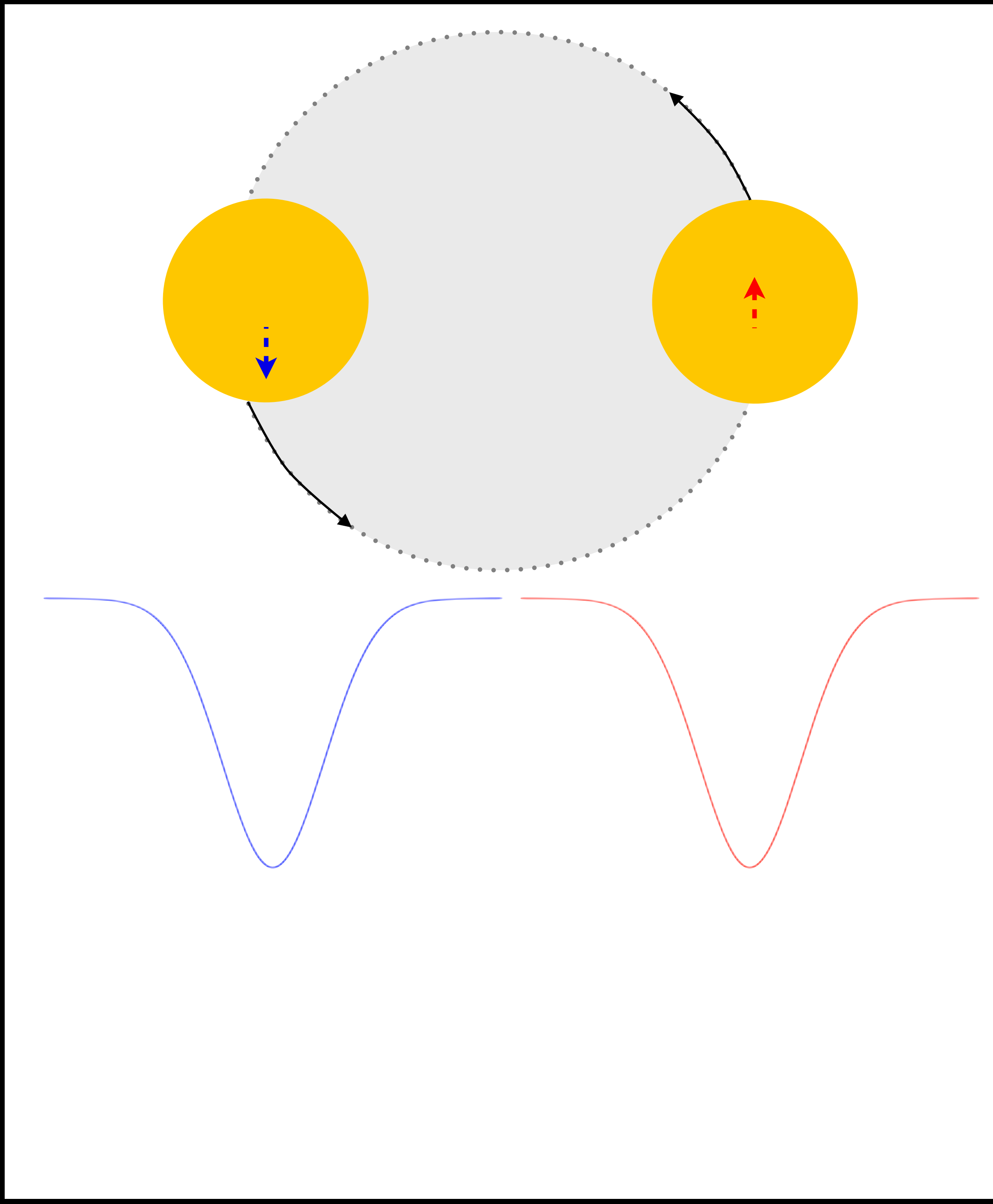


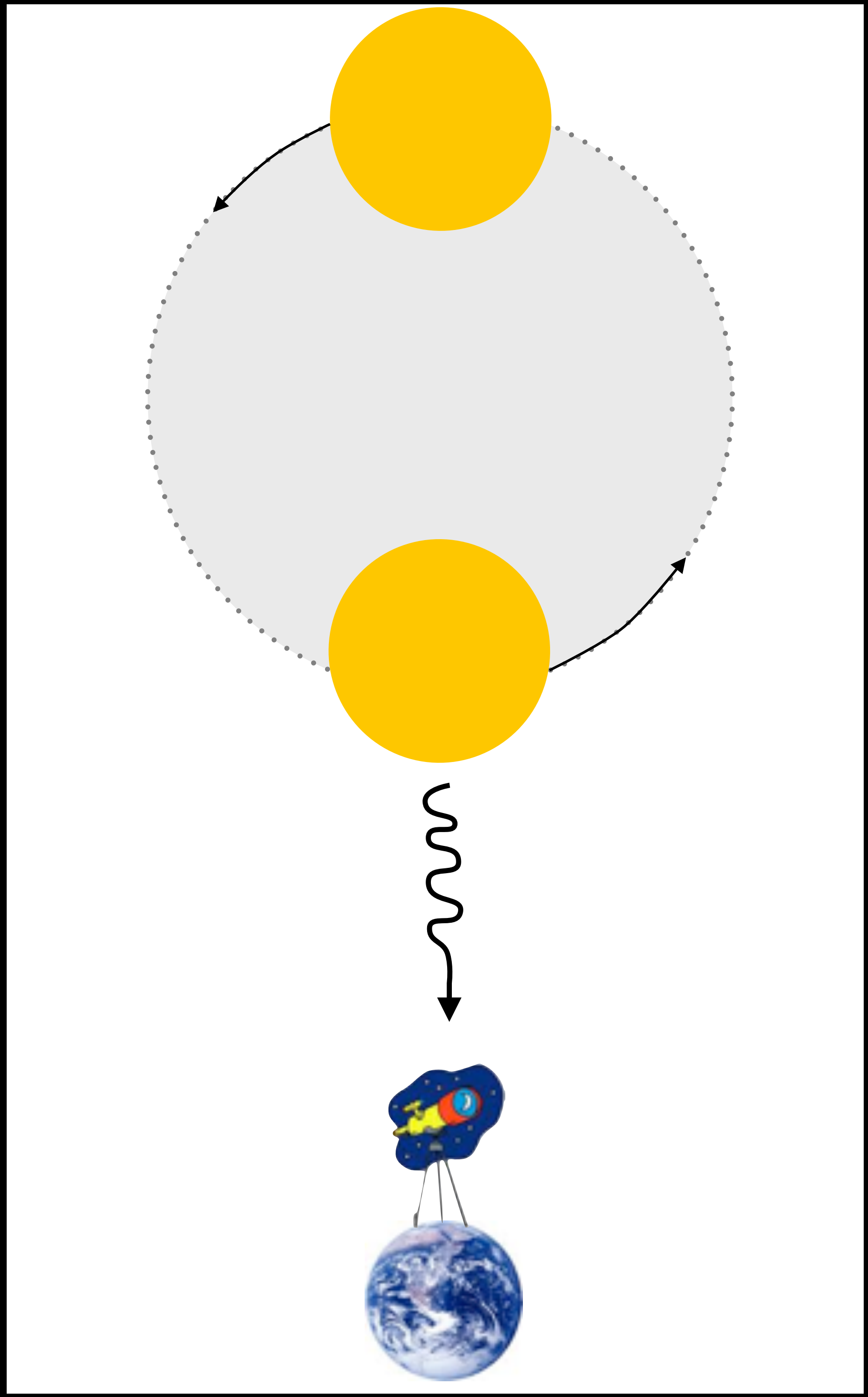
Spectrosopic Binary

- Which best describes the spectrum of the pictured system?

A) Two separate narrow lines, one red, one blue

B) Two lines, both blue

C) One line



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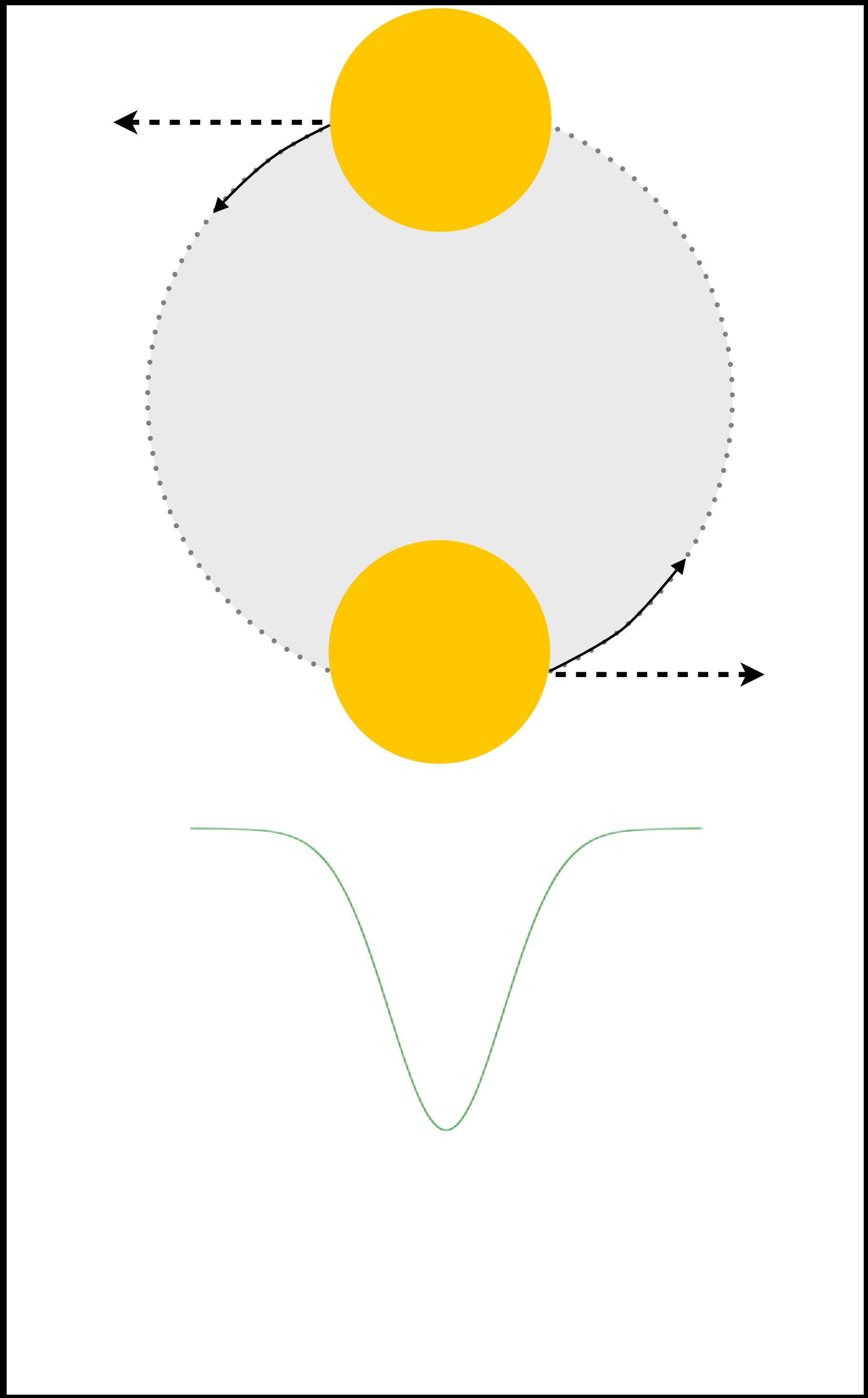
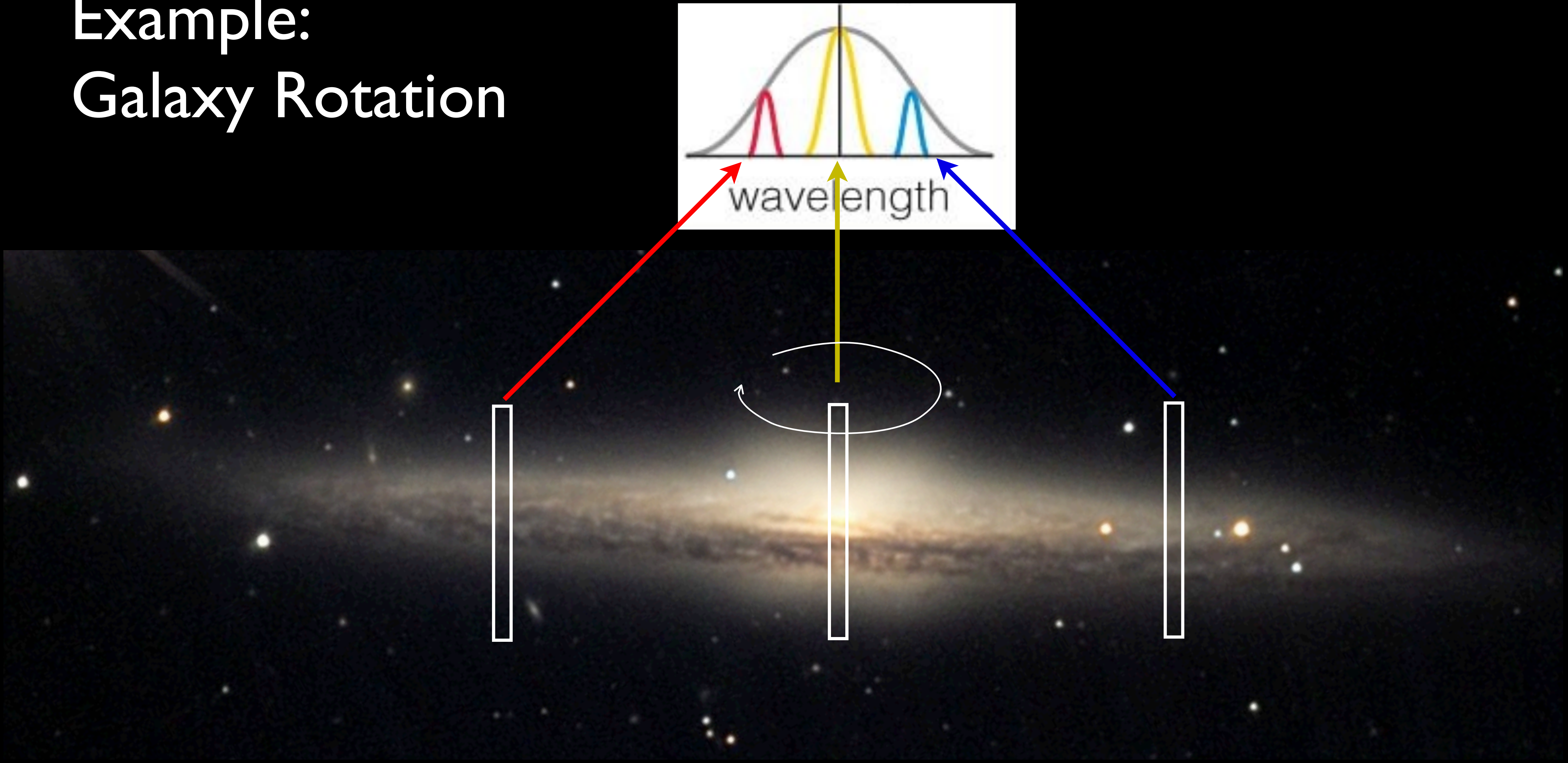


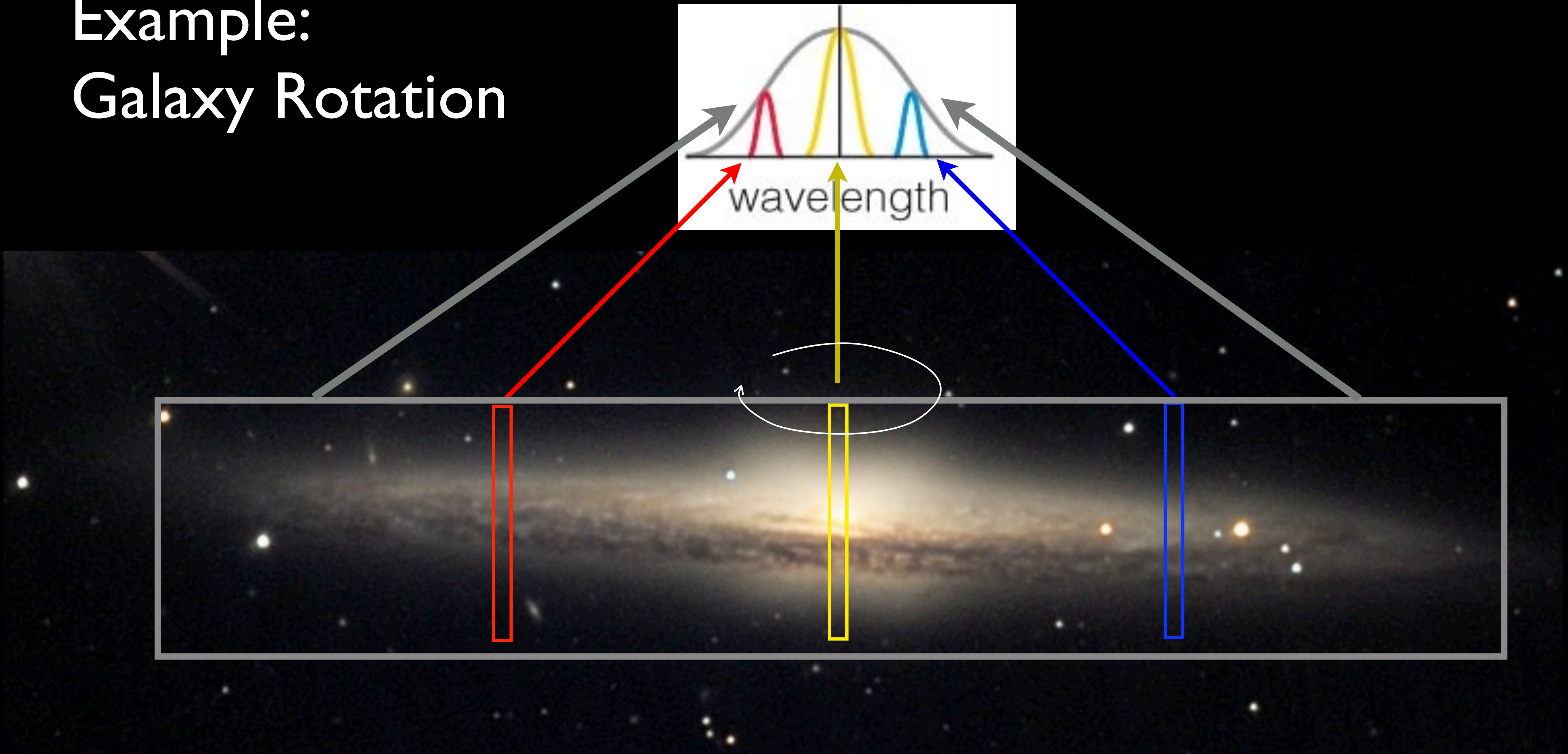
C)One line

Example:
Galaxy Rotation



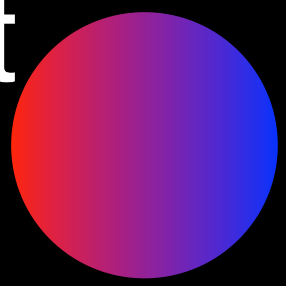
We can measure how galaxies rotate by observing the doppler shift along the disk

Example:
Galaxy Rotation

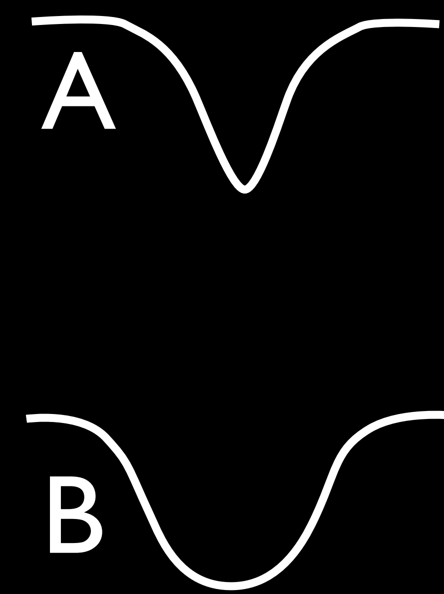


When you observe both sides of a rotating object at the same time, the lines blend together and smear

Clicker Question: Rotating Planet



- You observe the spectra of two planets. Planet A shows a narrow line, planet B shows a broad line. What can you conclude about the planets?



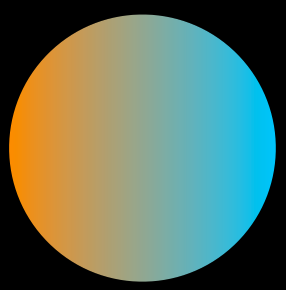
A) Planet B is bigger than planet A

B) Planet B is moving towards you faster than planet A

C) Planet B is moving away from you faster than planet A

D) Planet B is spinning slower than planet A

E) Planet B is spinning faster than planet A



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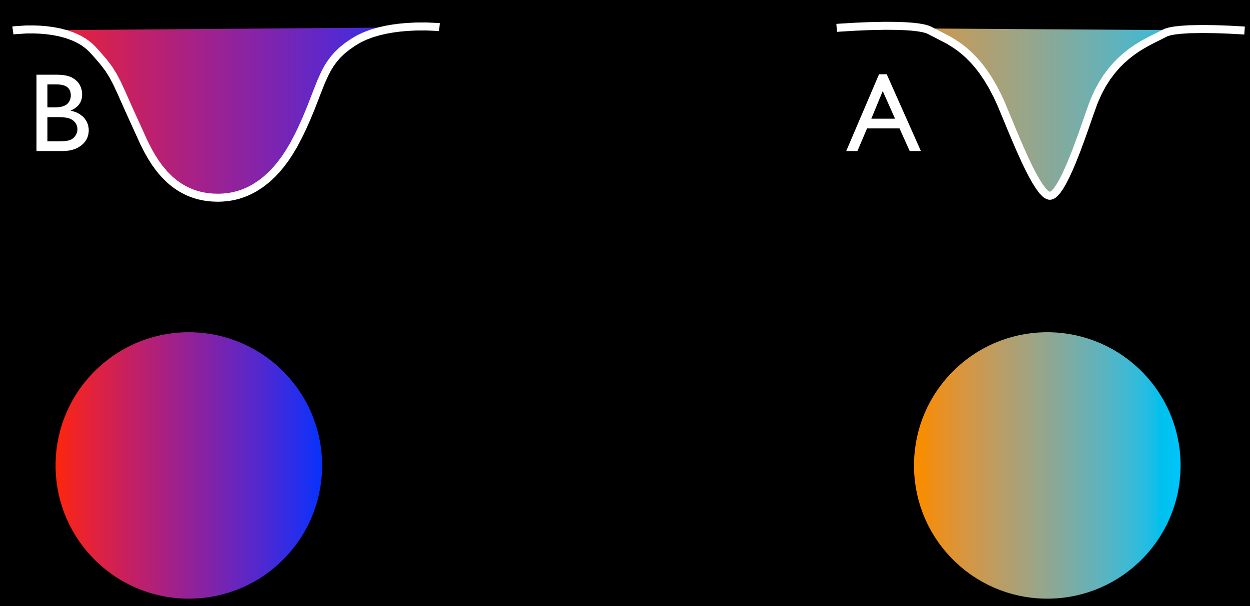


E) Planet B is spinning faster than planet A

Clicker Question: Galactic Rotation

- If you observe the whole galaxy at once, what will its spectrum look most like?

A) Two separate narrow lines: one red, one blue

B) One narrow line

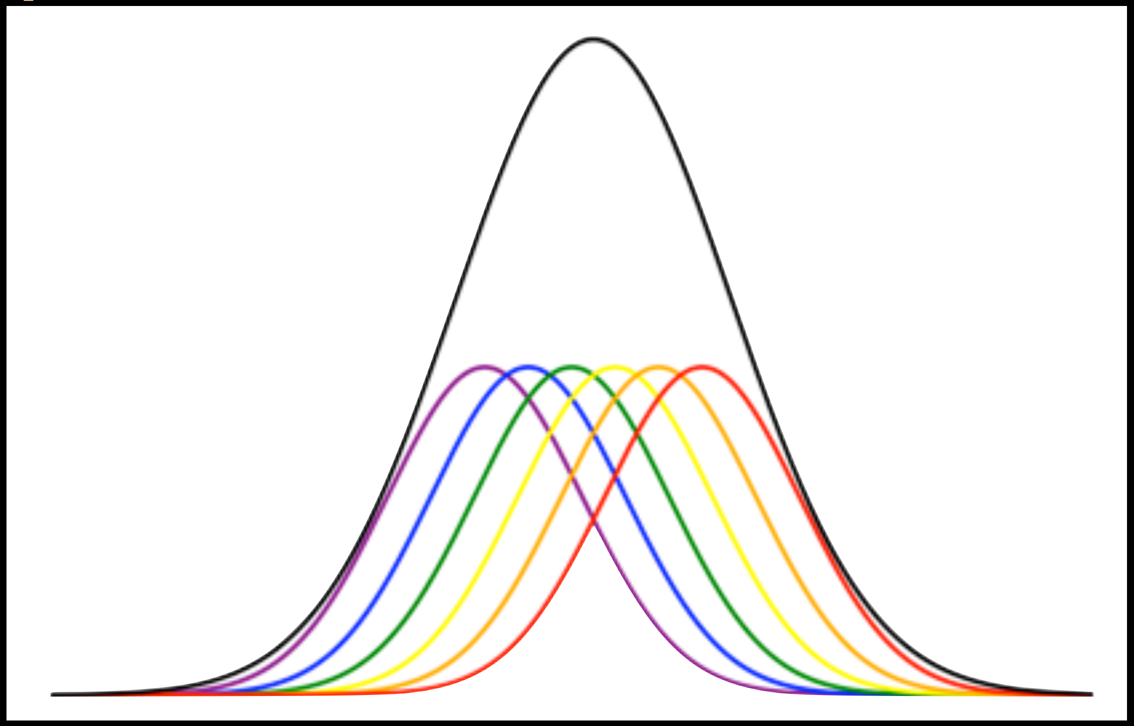
C) One broad line

D) No lines at all

Clicker Question: Galactic Rotation

- If you observe the whole galaxy at once, what will its spectrum look most like?

C) One broad line



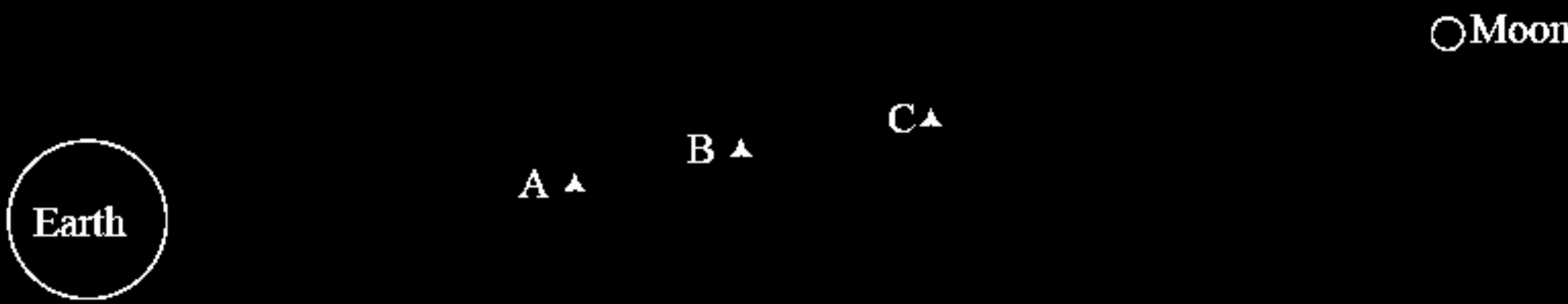
BREAK

Tutorials

- Newton's Laws (pg 29)
- Doppler Shift (pg 73)

TUTORIAL

- In this picture the Earth-Moon system is shown (not to scale) along with three possible Positions (A-C) for a spacecraft traveling from Earth to the Moon. Note that Position B is exactly halfway between Earth and the Moon.



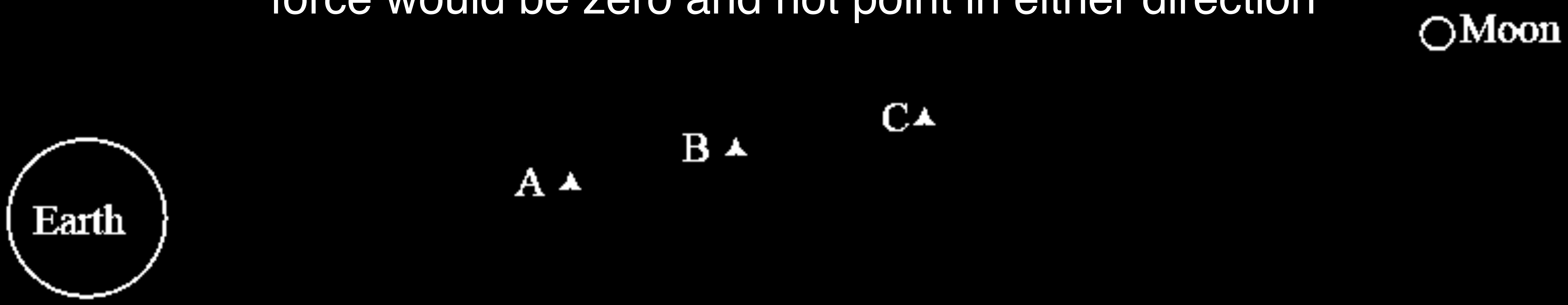
TUTORIAL

- In what direction would the net (total) force point if the space ship were moving very quickly toward the Moon when at Position "B"?

A) toward Earth

B) toward the Moon

C) Since the force on the spacecraft by Earth is equal to the force on the spacecraft by the Moon, the net (total) force would be zero and not point in either direction



TUTORIAL

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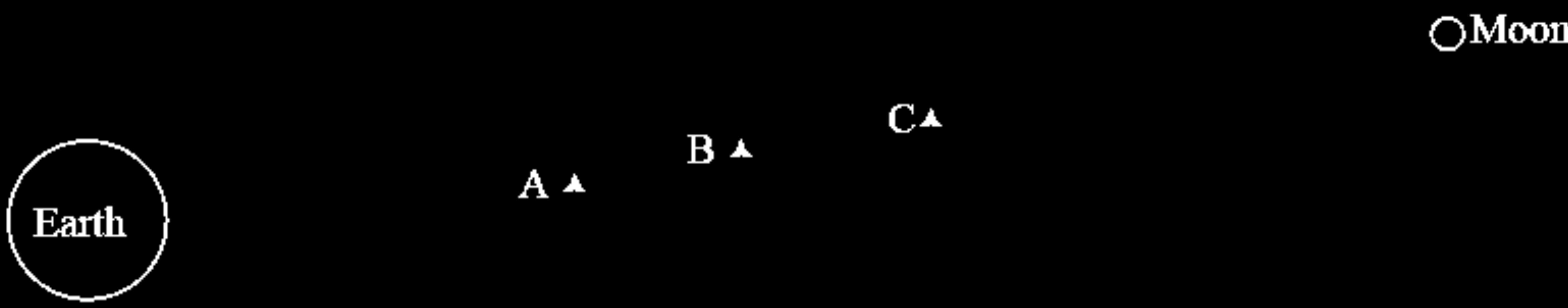
A) toward Earth

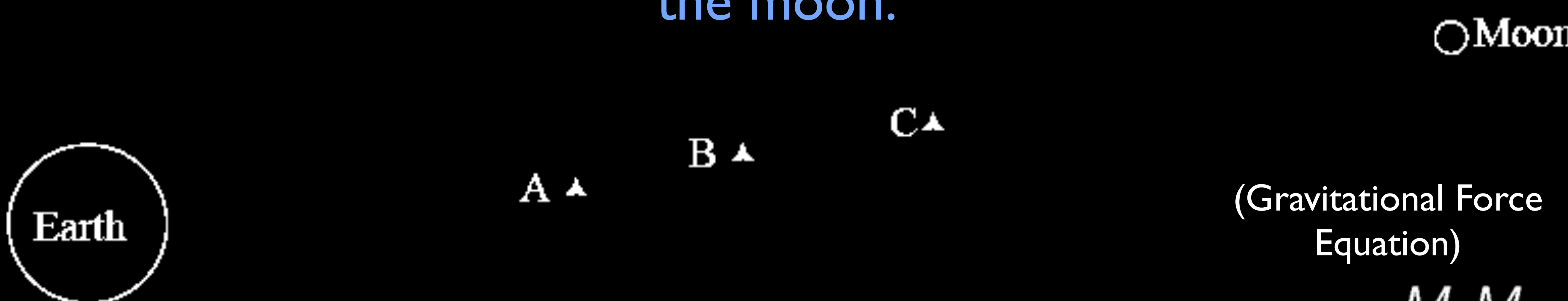


TUTORIAL

- In what direction would the net (total) force point if the space ship were moving very quickly toward the Moon when at Position “B”?

A) toward Earth

Because the distance from the spacecraft to the Earth and to the Moon is the same, the force only depends on the *mass* of the objects, and the Earth is more massive than the moon.



(Gravitational Force Equation)

$$F_g = G\frac{M_1 M_2}{d^2}$$

TUTORIAL

- At which position (A, B, or C) would the spacecraft feel the greatest acceleration?

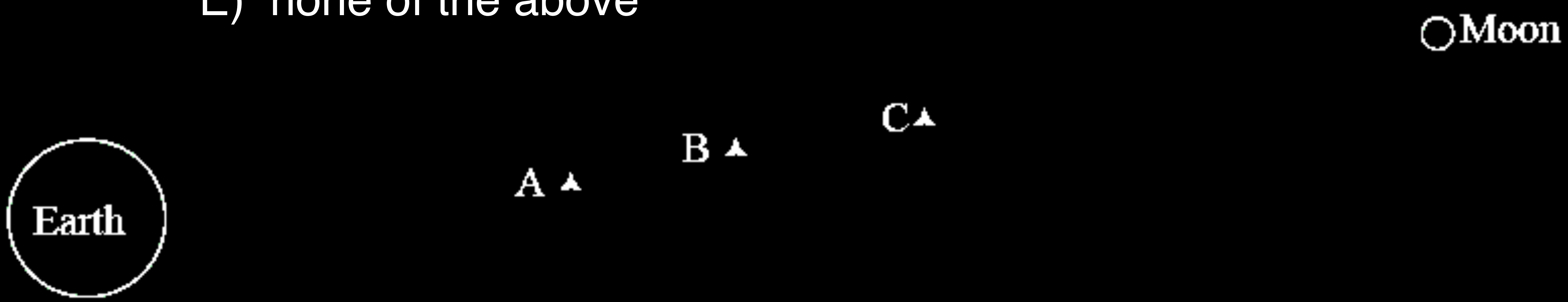
A) at position A

B) at position B

C) at position C

D) The acceleration would be the same at all positions

E) none of the above

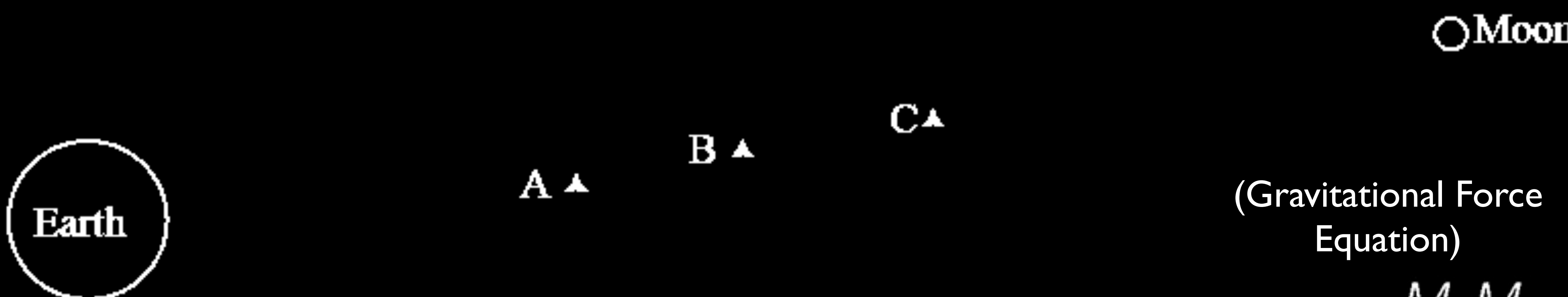


TUTORIAL

- At which position (A, B, or C) would the spacecraft feel the greatest acceleration?

A) at position A

The acceleration of the spacecraft depends on the total (net) force. At position A, the force from the Earth is strongest and the force from the moon is the weakest, so the total force is greatest.



(Gravitational Force Equation)

$$F_g = G\frac{M_1 M_2}{d^2}$$

TUTORIAL

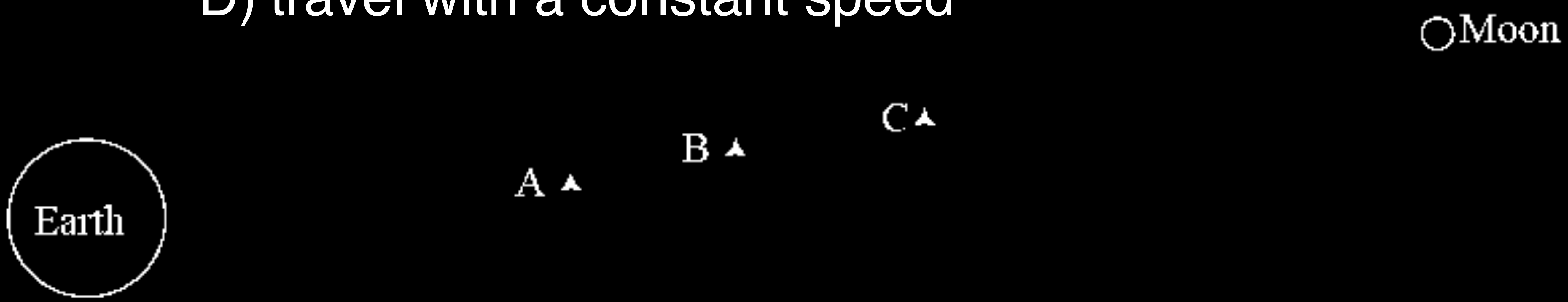
- What would the spacecraft do next if it were moving toward the moon when at position A?

A) speed up

B) slow down

C) travel with a constant acceleration

D) travel with a constant speed



TUTORIAL

- What would the spacecraft do next if it were moving toward the moon when at position A?

B) slow down

The spacecraft is moving towards the Moon but being pulled by gravity back towards Earth.