Themed: 05-01

Two reflection types. How do we know something is there? Why do we think something is there, when it’s not?

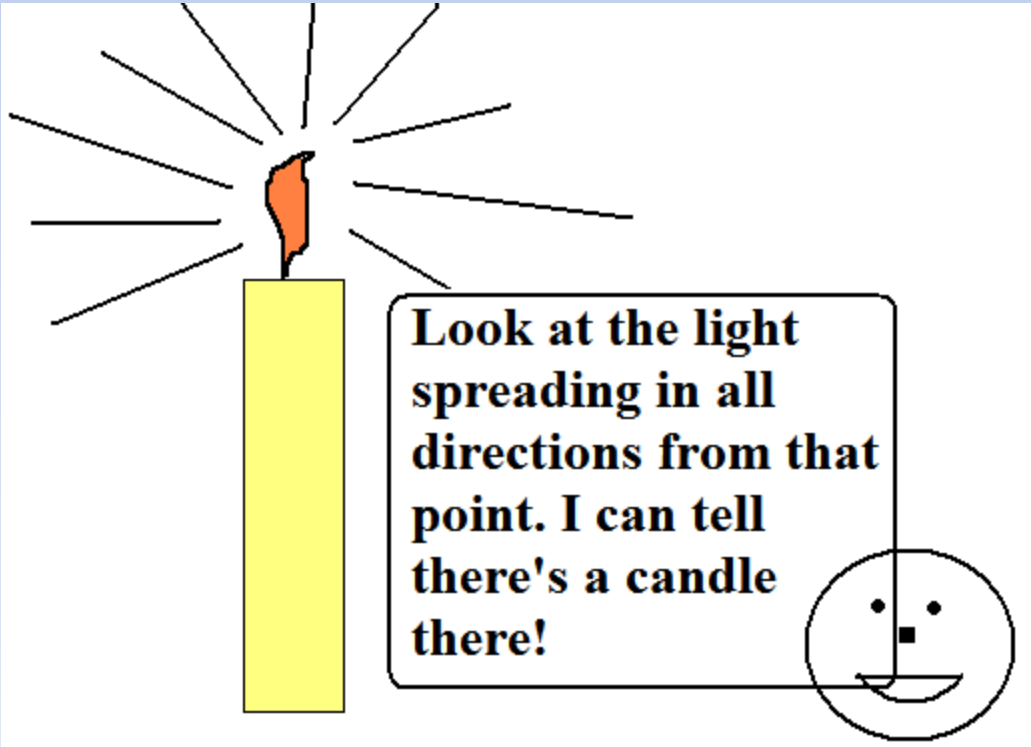
Reflection – two types

- Light is either: absorbed, transmitted, or reflected
- Reflection: like a basketball bouncing back from floor
- Two kinds of reflection:
- **Diffuse** reflection
  - Off a "rough" surface – bounces back unpredictably
  - Matte, not polished surface (like bball off gravel)
  - Can't form images this way
  - White paper (reflects all light, in random way)
- **Specular** reflection
  - Off a "smooth" surface – bounces back predictably
  - Shiny, polished surface (like bball off wood floor)
  - Can form images (in MIRRORS!)
  - Mirror (reflects all light, in orderly way)

How do I know something is there?

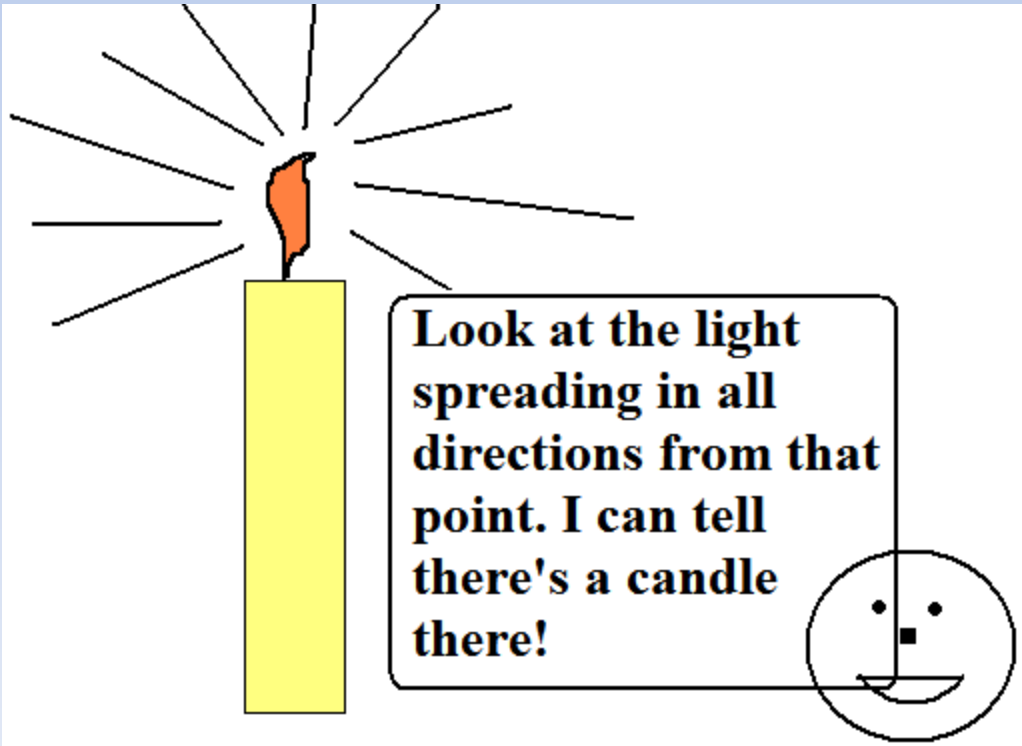
Mirrors..Why do I think there's a man behind the mirror who looks like me?

- Our brain believes that light travels in straight lines, spreading in all directions from a point of origin



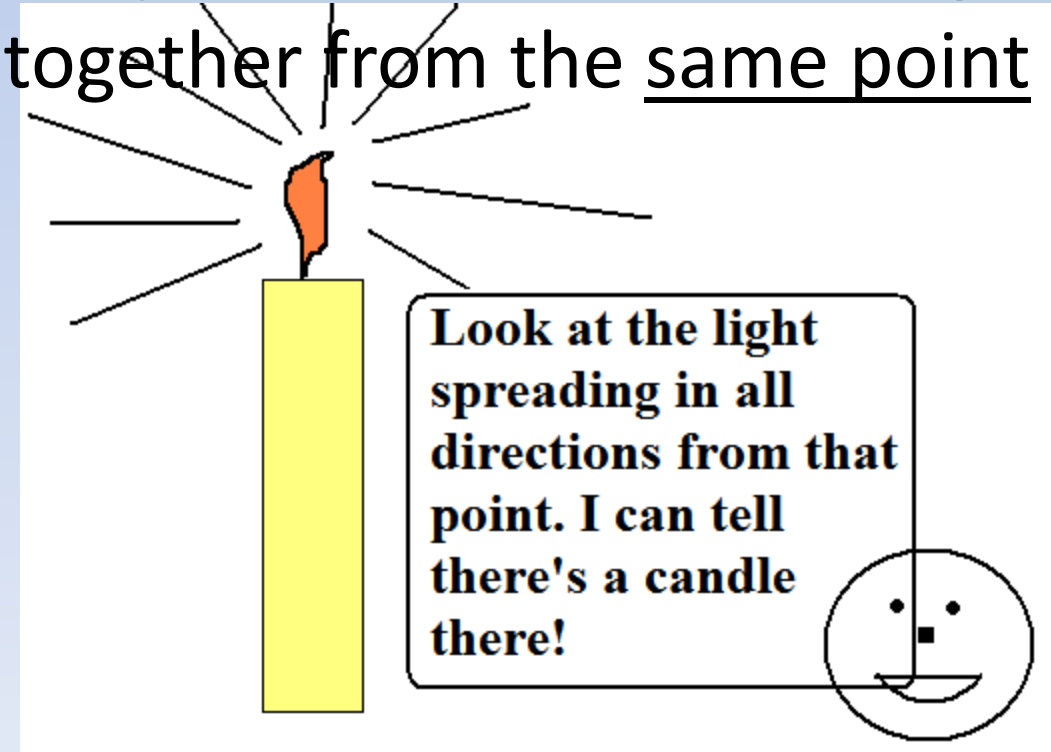
Why do we think something is there when it's not?

- If it SEEMS to us that light is spreading out from some point in space we believe an object is at that point
- The "apparent" object is called an image
- The object is the real thing, the image the "fake"



Mirrors

- We see where images form by tracing the way light rays bounce off of mirrors
- Mirrors must be polished smoothly so they have specular reflection (NOT diffuse)
- An image will only form if the reflected light rays all come together from the same point

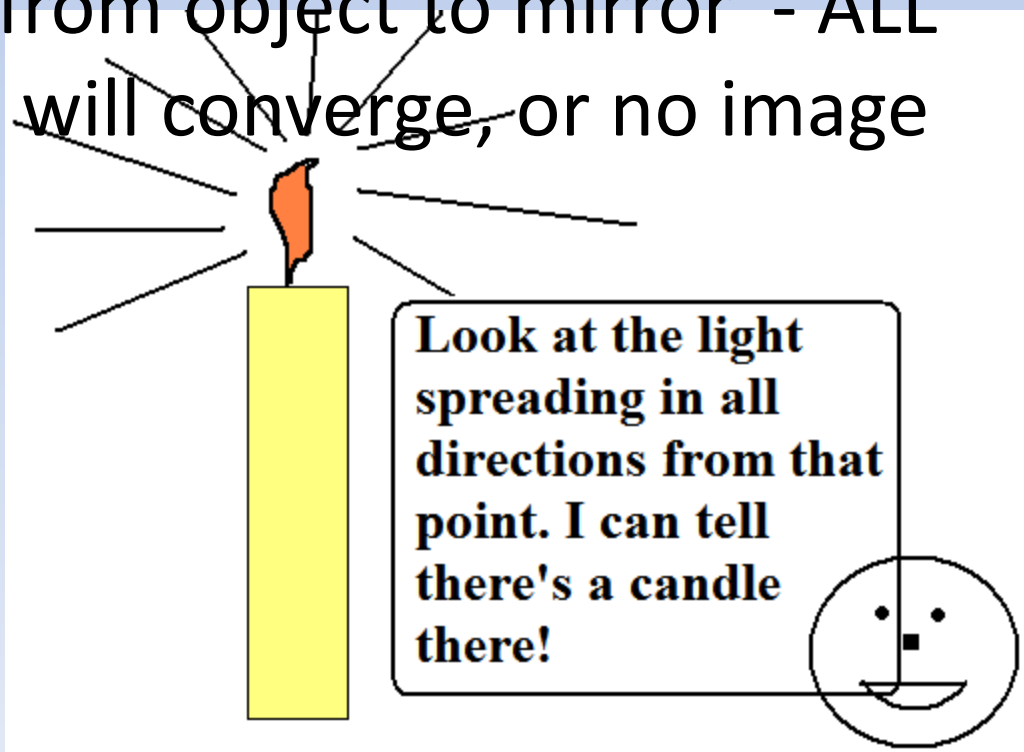


Themed: 05-02

Ray tracing, reflection angles, flat mirror example in detail

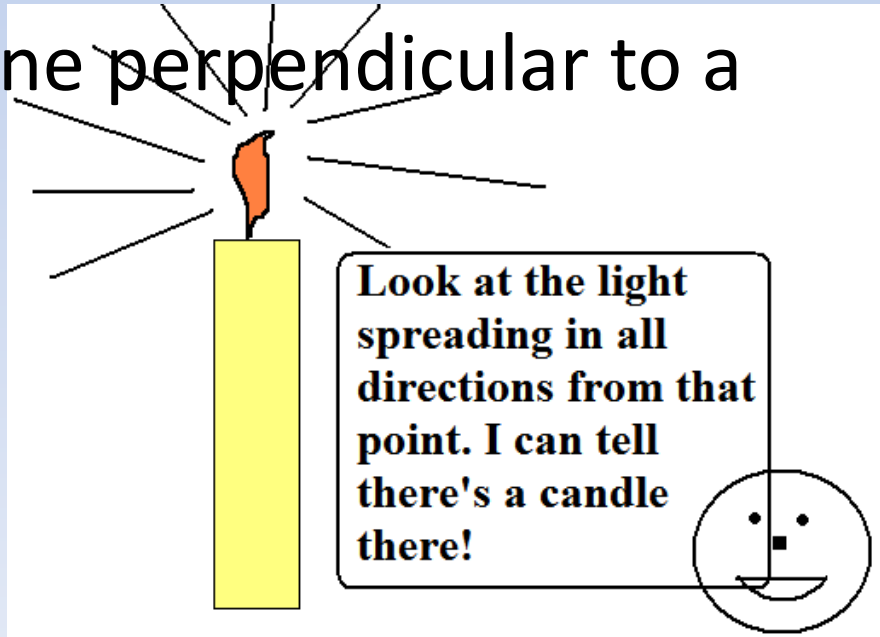
Ray Tracing – The big picture

- Pick a point on the object
- Light rays diverge (spread out) from that point
- See POINT where reflected light rays come together
- That point is the image of the original object point
- Just start drawing rays from object to mirror - ALL the reflected light rays will converge, or no image will form!
- Ray tracing is just that!



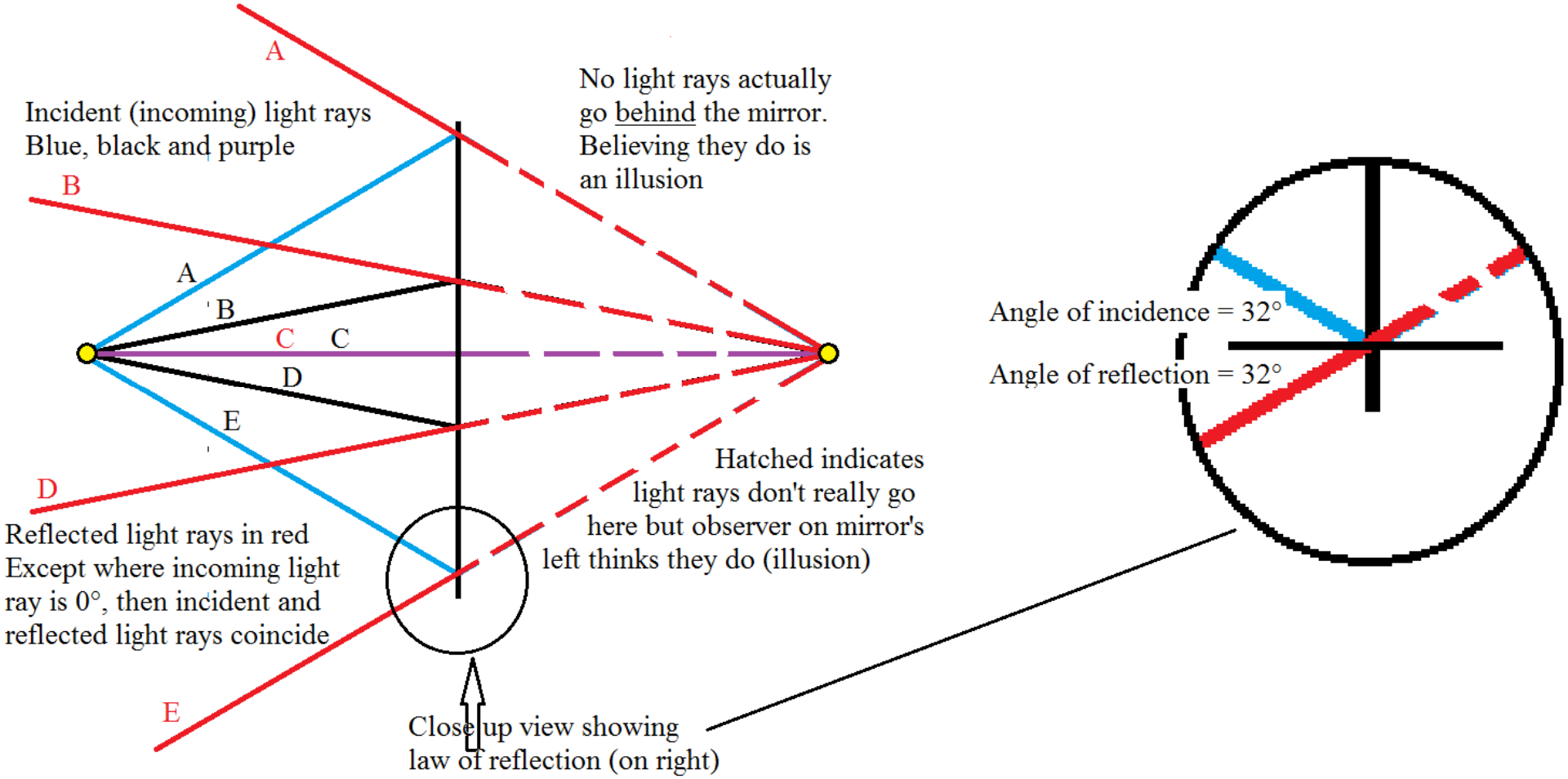
Ray Tracing – Reflection Angles

- Ray tracing is tracing **reflected** rays from a mirror
- Geometry rule for reflected light rays
- Law of reflection (specular reflection)
  - Angle of incidence = Angle of reflection
- Angles are measured relative to a “normal”
- We’ll use normals in refraction optics too, know it
- A normal is a constructed line perpendicular to a surface
- See example/demo next!



Ray Tracing – Flat Mirror (detailed example)

- Pick a point on the object. Light rays spread in all directions from that point
- See POINT where reflected light rays come together
- That point is the image of the original object point
- Just start drawing rays from object to mirror - ALL reflected light rays will converge, or no image forms!
- All observed agree of image's location (A, B, D, E)…C's view is blocked by object

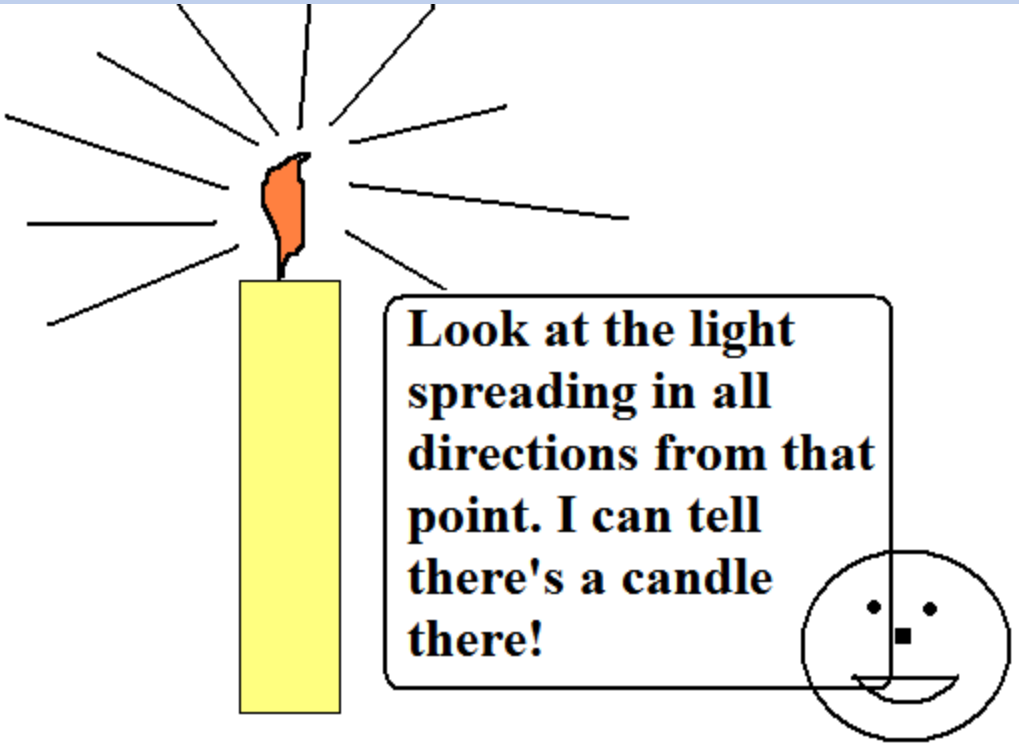


Themed: 05-03

Ray tracing summary, cool curved-mirror geometry, convex/concave sample

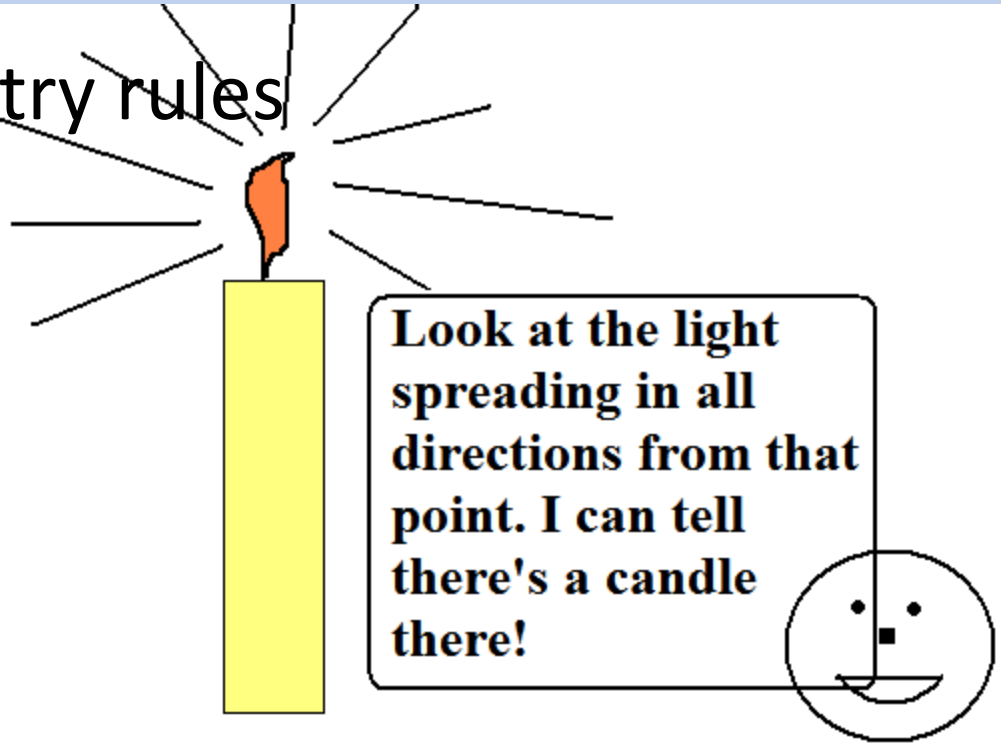
Ray Tracing - Summary

- Summary:
  - Pick a point on the object
  - Light rays diverge (spread out) from that point
  - See POINT where reflected light rays come together
  - That point is the image of the original object point



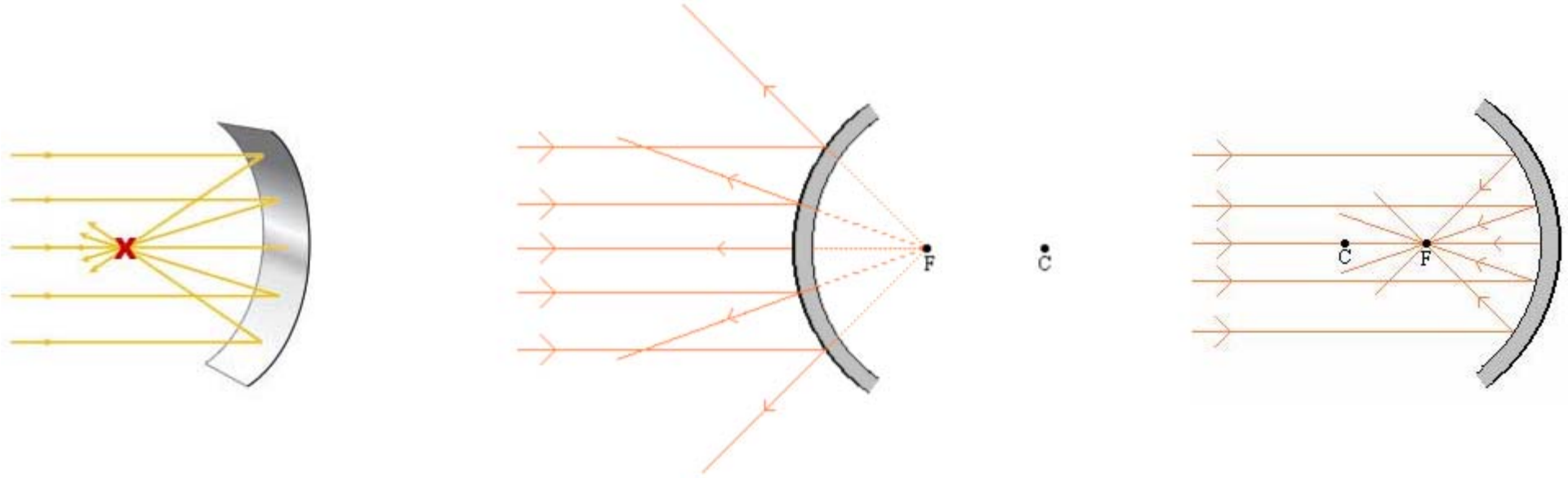
Cool Curved-mirror geometry

- Flat mirrors – too obvious,
  - Stand 4 ft front of mirror, image is 4 ft behind mirror
  - Duh! Don't need to ray trace for this!
- Curved mirrors, not so obvious
- Measuring angles too hard
- Use special case geometry rules



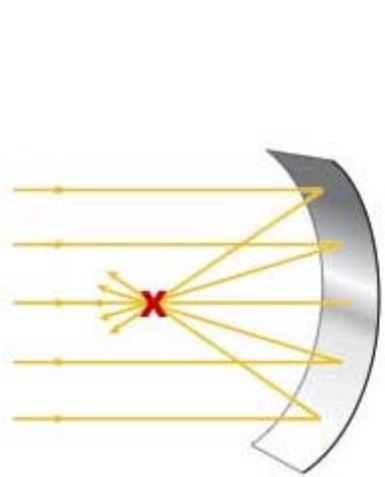
Cool Curved-mirror geometry

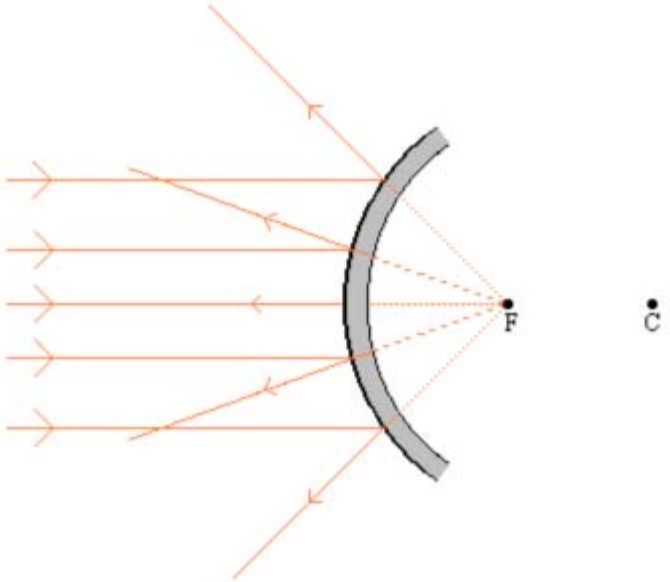
- Cool curved-mirror properties
- Below: cross-section of a partial sphere
  - Focal point, half way between mirror and center pt.
  - Horizontal light rays reflect through focal point
  - Focal rays bounce back horizontally
  - Center point: ray bounces straight back

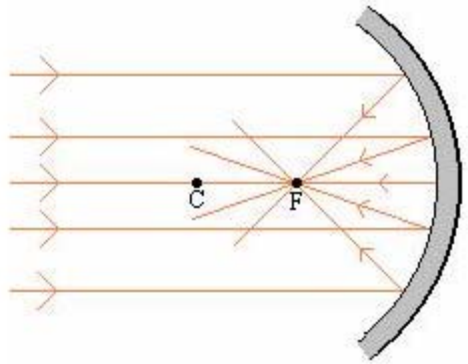


Ray Tracing – convex/concave sample

- Goal:
  - Start with a single point of light (candle flame tip)
  - Find single post-reflection point where light re-converges, or appears to
  - The is where the image (of candle flame tip) SEEMS to be
  - Two lines intersect at a pt, so pick two easiest rays
- Could use protractor & find angles (too hard!)
- Use Two easiest of 3 principal rays (straight edge is all)
- Three principal rays:
  - Focal ray: passes through focal point, reflects horizontally
  - Horizontal ray: Comes in horizontally, reflects through Focal point
  - Center ray: passes through center point, reflect through <u>same</u> point

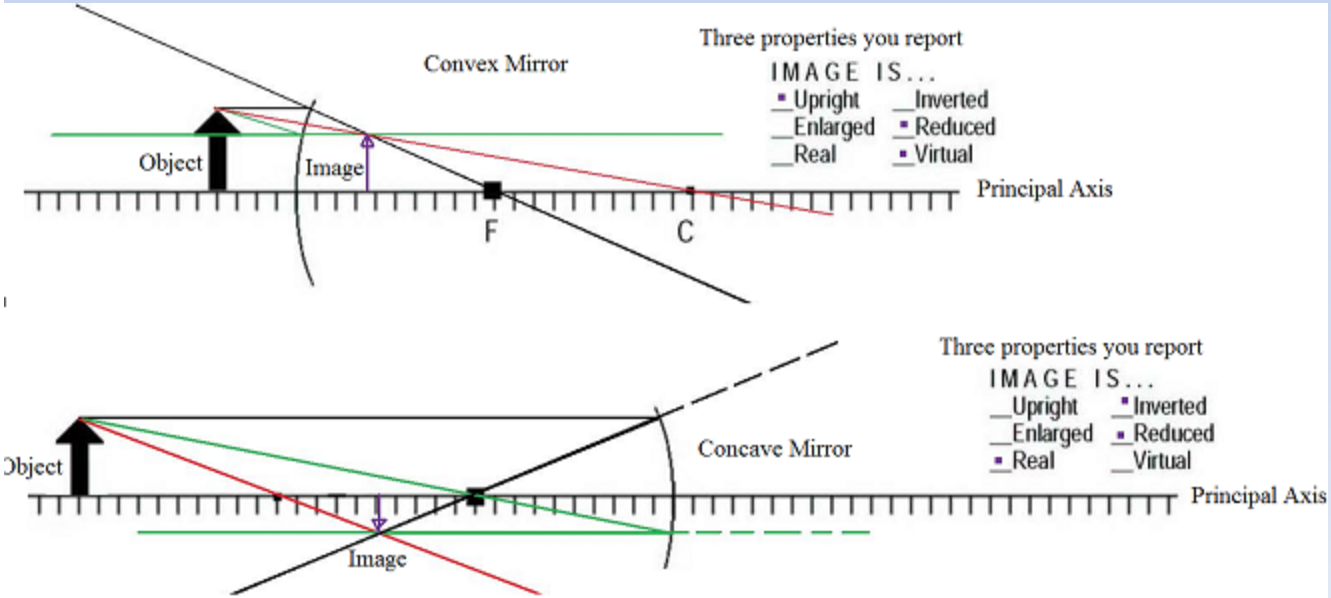






Ray Tracing – convex/concave sample

- Important stuff
  - Bottom of plane (line) candle is on is “principal axis”
  - We analyze only TIP of candle flame
  - Draw TWO SIMPLEST principal rays, intersection is where image of tip of candle flame defines image location
  - Always show arrows for images & base on “PA”
  - Identify three image properties (u/I, E/R, R/V)
  - Convex mirror is “boring”, all images have same properties
  - Real image: When light “really” comes together (can project image)
  - Virtual image: When light doesn’t really come together (can’t project)

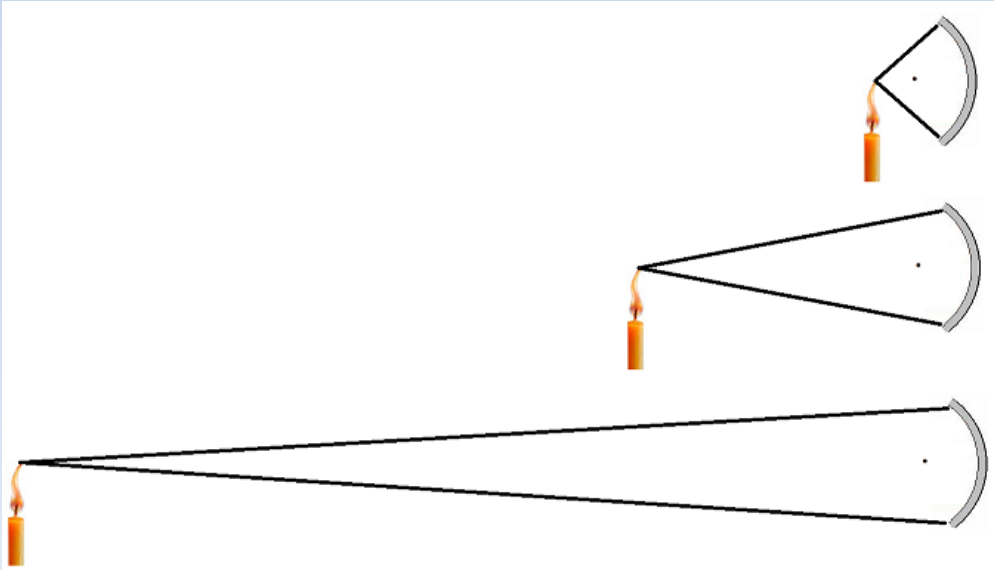


Themed: 05-04

Source of horizontal light rays, Car mirrors, Other mirrors, Satellite Dish, Cheat sheet advice

Horizontal rays - from distant light sources

- Cool properties is why its easy to use parallel light examples
- For any distant light, rays come in nearly parallel
- Pick a point on the object
- Look at light rays below, notice how lines get MORE parallel at candle gets more distant?
- A **distant object** sends horizontal rays to a mirror
- Time for real image demo?



Mirrors –Basic Properties/Car uses

- Three types in your car. You're a driver, know all of them!
- Flat/Planar
  - Images are same size - no distortion
  - Good rear view mirror – can judge if a car is closing on you
  - Good driver side mirror too
  - Limited field of view (blind spot)
- Convex
  - Makes object smaller
    - bigger field of view
    - Distorted size makes speed judgment hard
- Concave
  - Car headlights (light at focal point makes reflected light beams)
  - Since beam, can direct light where you want it
    - illuminate road
    - Don't blind driver headed toward you
    - Don't waste light illuminating peripheral, etc.

Some other mirror uses

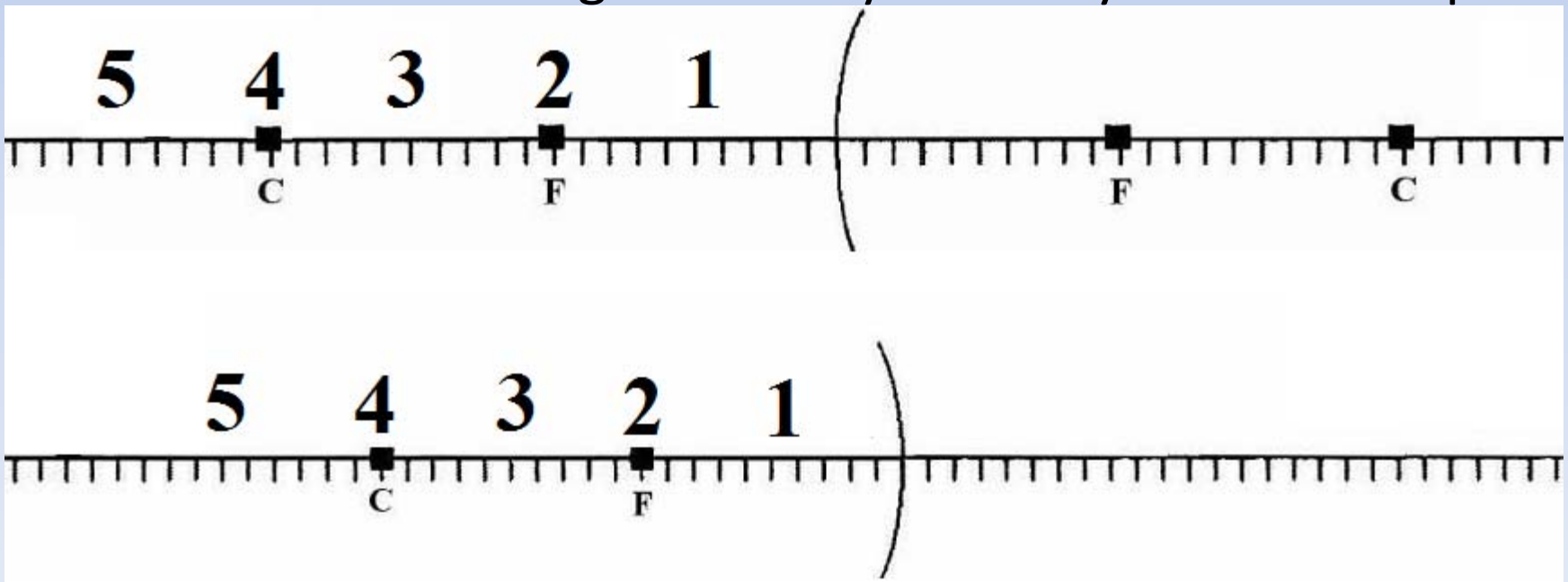
- Make-up mirrors (which kind can enlarge!)
- Mirror to start a fire (which kind can converge light rays!)
- Anti-theft/peek around corners
- Flash lights (create beams)
- Household (grooming, etc.)
- Optics (microscopes, telescopes, cameras, etc.)

Satellite dishes – Special Concave Mirror

- Specular reflection happens with SMOOTH surface
- Satellite dish is very smooth compared to light it gathers (a polished mirror for THAT type of EMR)
- Example, Direct TV Dish
  - Satellite: 22,400 miles over equator (geocentric orbit)
  - Point dish to south (tilted toward equator)
  - Sends 18.5 GHz EMR (microwaves, $\lambda = 1.6$ cm (0.6 inches))
  - Light mirrors must reflect $\lambda = 0.00005$ cm
  - Polished means smooth compared to the EMR it's reflecting

Themed **ONLY** Cheat Sheet

- **Themed** gets a 3” x 5” cheat sheet on this test
- You hand in with test and never see it again!
- Make it soon, get used to it (part of cheat sheet)
- Use simulation to make results table:
  - 5 locations x 3 properties
  - For both mirrors (convex, concave)
  - Here are the five regions…can you do it yet? More help?



More Table Hints?

- OK, I'll give you some more hints, but I won't do it all for you!
- First though, know flat mirrors too (up, same size, virtual)
- **Meaning of regions**: 1: Object relatively close to mirror surface; 2: Object on focal pt. 3: Object between focal and center; 4: Object on center; 5: Object beyond center
- Possible Table Format (5 regions x 3 properties)
- Go to simulation and start discovering!

Region	Up/Inverted?	Enlarged/Reduced?	Real/Virtual
1)Close			
2)Focal			
3)Focal-center			
4)Center			
5)Beyond center (far)			