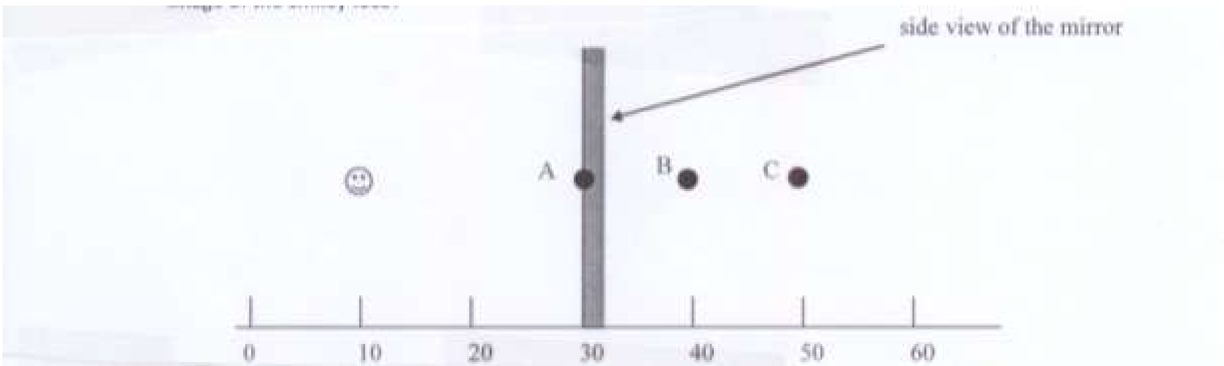
**Exam 2**

**Physics 221**

Name: ___________________________

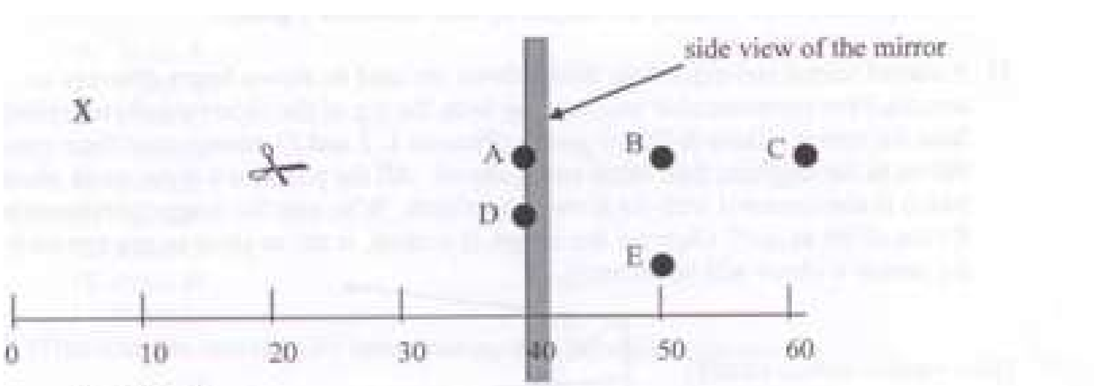
## **Use the scantron answer sheet for questions 1-19** (3 points each)

1. There is a smiley face 20 cm in front of a flat mirror. Which point is closest to the location of the image of the smiley face?




*C The image will be the same distance behind the mirror as the object is in front of it. It doesn't matter where you are located when looking at the image, it's always at the same spot behind the mirror.*

2. You are looking at the reflection of a pair of scissors which are approximately 20 cm from a flat mirror. Your eye is at the location indicated by the X below. Which point is nearest to where the image of the scissors appears to be?




*C The image will be the same distance behind the mirror as the object is in front of it. It doesn't matter where you are located when looking at the image, it's always at the same spot behind the mirror.*

3. Derek stands in front of a flat mirror that is one half of his height and fastened to a vertical wall. He is more than a meter away from the mirror, but less than 30 meters away. The top of the mirror is located at Derek's eye level. How much of his body length can Derek see in the mirror?


From eye level to his feet. He can't see the top of his head because light that comes from the top of his head and hits the very top of the mirror, will reflect into his face about at his mouth. He can see his feet fine because the light from his feet that hit the bottom of the mirror will reflect into his eyes.

4. The focal length of a plane mirror is

   ∞ Consider a concave mirror, as you increase the radius, the mirror is less curved (creates a bigger circle if you traced it all the way around. As the radius becomes larger, the mirror is less curved. Finally for it to be flat, the radius would have to be infinitely large.

5. Which of the following is ***not*** a limiting factor to humans' visual acuity

   **Spherical aberration** is not a problem because the index of refraction of the lens of a human's eye is ever so slightly larger at the outer rim to bend light more. This causes all the light to converge at one nice focal point. A perfectly spherical lens made from the exact same material does not focus at a point. Light coming through the outside edges will focus at a slightly different spot.

   - Chromatic aberration is a problem since different colors of light refract at different angles.
   - Foveal cone size limits how close two objects can be and have our eyes identify the space between them.
   - Diffraction causes a circular smudge for very small objects.

6. Laser light is used to measure the thickness of a human hair. The laser is 632 nm, the hair is 2.5 m from the wall, the space between the maximum and the first bright spot is 1.75 cm. What is the path difference for light that creates the *second bright* spot?

   The path difference is equal to one wavelength for the first bright spot, two wavelengths for the second etc… In this case we want the 2nd so 2*632 nm = **1264 nm**

7. Using the information from question 6 above. Find the thickness of the hair.

   $\boldsymbol{y_m = \frac{m\,\lambda\,L}{d}}$ This is the equation for a double slit interference pattern. Y is the distance from the center of the brightest spot to the next bright spot. When shining laser light on a hair, the hair acts as the separation between two slits. So we need to find $d$

   $\boldsymbol{d = \frac{m\,\lambda\,L}{y} = \frac{632\ x\ 10{-}9\ m\ 2.5\ m}{0.0175\ m}}$ = **9.0 x $10^{-5}$ m or 90 μm**

8. What is the spacing between each slit in a diffraction grating that has 850 slits per centimeter?

   This tells us that for every centimeter there are 850 slits. To find the space of one slit simply take 1 cm and divide it by 850 slits to get cm/slit. 850 / 0.01 m = **1.18 x $10^{-5}$ m or 12 μm**

9. When light travels from air into a material with a higher index of refraction (such as water or glass) what changes?

   **The wavelength of the light** but the frequency cannot change – try to visualize the frequencies being different on either side of the interface. Sometimes they hit each other, other times they both move to the right – it would be a mess and make no sense.

   **The speed of the light slows** when it moves into a material with a higher index of refraction.

10. What is refraction?

    When light bends as it travels into a material where it changes speed.

11. Light reflects off of a surface.

    Only if the index of refraction changes at the surface which is why you cannot see a test tube dipped into vegetable oil. The two materials have the same index of refraction so light does not bend at the interface so you can't tell anything is there.

12. Light having a speed in air of $3.0 \times 10^8$ m/s enters a liquid of refractive index 2.0. In this liquid, its speed will be:

    $n = v_o/v$ $2 = 3.0 \times 10^8$ m/s / $v$ so $\boldsymbol{v}$ **= 1.5 × $10^8$ m/s**

13. Light is incident on a piece of glass, n = 1.5, as shown in the diagram. The incident light makes an angle of 30° with the surface of the glass. What is the angle of the light with respect to the normal just after it enters the glass?

    $n_1 \sin \theta_1 = n_2 \sin \theta_2$

    $\theta_1 = 60^o$ because the angle must be measured with respect to the normal.

    $1 \sin 60^o = 1.5 \sin \theta_2$ $\boldsymbol{\theta_2 = 35^o}$

14. Using the scenario in the question above, determine the angle of the reflected light off the surface of the glass. (measure the angle with respect to the surface of the glass)

    The question specifically asks you to measure with respect to the glass. Law of Reflection:

    $\theta_i = \theta_r$ since the light comes in at 30 it will reflect at **30 °**

15. Consider diamond which has an index of refraction of 2.42 and air which has an index of refraction of 1.0. When will there be a critical angle?

    When light goes from diamond to air. Light entering the air from the diamond will bend away from the normal. Once the incident angle is large enough, the bend away will be 90 degrees or more and the light will only reflect back in.

16. A concave mirror is a

    Converging mirror and has a positive focal length. The focal length is positive because it's in front of the mirror where the light goes after reflection.

17. What are the conditions for a person to see an image formed by a lens?

The person's eyes can be anywhere behind the lens and image. Our brains can trace the rays back to where they appear to come from so we can figure out what the image is without having our eye at the image.

18. What are the conditions for an image formed by a lens to be focused clearly on a screen?

The image must be real

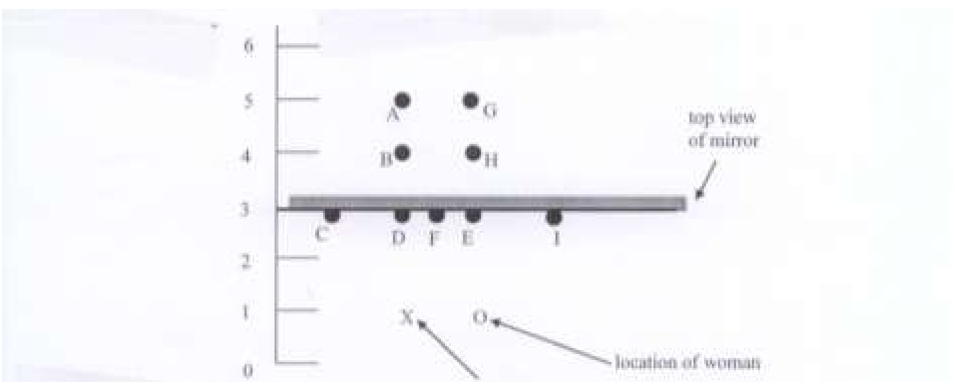
The screen must be at the location of the image. Otherwise the rays of light will not be at the necessary spots to make a clear image on the screen.

19. When prescribing corrective lenses where do we want the image to be?

The image should form somewhere between the person's uncorrected near point and far point. This is because the eye can focus on objects between the far and near point so if the glasses make an image in that area, the eye can focus on it. This means the image has to be virtual since the image will be on the same side of the corrective lens (glasses or contacts) as the object and light coming in.

**Provide your answers and show all work for questions 21 – 23 on this sheet and additional blank sheets (not the scantron).**

20. (3 pts) An observer is located at O. Where does she see the image of the X?




**A** The image will be the same distance behind the mirror as the object is in front of it. It doesn't matter where you are located when looking at the image, it's always at the same spot behind the mirror.

21. (20 pts) A person looks into a magnifying vanity mirror and notices that if they stand 5.0 meters from the mirror, their image is completely blurry but if they back up they are now upside down!

From the question information you know that the focal point must be at 5.0 meters. If the image is blurry it's because the rays are heading off parallel and never form an image. Also a vanity mirror creates an upright image for near objects and inverted images for far objects. The blurry spot is where the image flips from upright to inverted which happens at the focal point.

a. Is this a concave or a convex mirror? How do you know?

Concave because the focal point is in front of the mirror. Convex mirrors have focal points behind the mirror which is why they always produce the same kind of image.

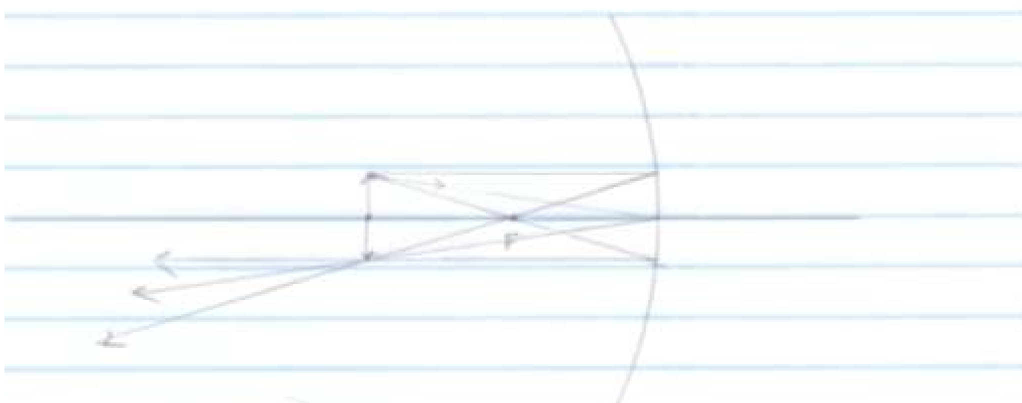
b. What is the focal point and the radius of the mirror?
Focal point is 5.0 m and the radius is 10 m since $f = R/2$

c. If a person is 10 meters from the mirror, where is their image located and what is its magnification? Use the "thin lens equation" to calculate the image location.

$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} = \frac{2}{R}$ $\frac{1}{10\,m} + \frac{1}{s'} = \frac{1}{5.0\,m}$ **s' = 10 m** $M = \frac{h'}{h} = \frac{-10\,m}{10\,m} =$ **-1**

The image is real, inverted and the same height as the object.

d. Draw an accurate scale ray diagram of the situation in c.




22. (20 pts) A person has a far point of 50 meters (5000 cm) and a near point of 1.5 meters (150 cm).

a. Is this person nearsighted or farsighted? Why?
They are farsighted because they can see far away well but not close. 1.5 meters is longer than your arm! 50 meters is half a football field and deeper than a classroom so they see far just fine.

b. Do they need a diverging or converging lens or both to correct their vision?
They need a converging lens to correct their vision. When you're farsighted, images are created behind the retina so a converging lens will help form the image in a shorter distance.

c. Determine the refractive power for the appropriate corrective lenses.
$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} =$ P $\frac{1}{0.25\,m} + \frac{1}{-1.5\,m} = \frac{1}{f} =$ **P = 3.33 D**
I used 0.25 m for my object location because the person wants to be able to see a close object. -1.5 meters is my image because the person's eye can see something clearly at 1.5 meters and it's negative because 1.5 meters in front of the corrective lens is not where the light actually is. The light actually goes through the lens and into the person's eye. But the image needs to appear as if it's coming from a location that the person can focus on naturally.

d. Draw an accurate scale ray diagram of the lens with an object that produces an image at his uncorrected near point of 1.5 meters.