MT2 132 S15 Schwartz Name_____

1. I want to lift a block of concrete that is too heavy for me, so I devise a hydraulic system. The primary cylinder has a piston diameter of 1 cm and the cylinder I put under the block has a diameter of 20 cm. I use a lever to put a force of 1000 N on the primary cylinder.
   a) Please make a very quick sketch of this technology.
   b) What is the pressure in the hydraulic fluid?
   c) What is the force exerted by the cylinder under the block?
   d) My hydraulic device gives me more force than I put into it. Am I getting something for nothing? Am I violating some law of physics? Please explain. It's energy not force that must be conserved. This is a force multiplier, like a lever. However, the work you put in must be equal to the work you get out. So the piston you are pushing on must move further (by the same ratio as the forces are different) than the piston under the concrete block. You can also see this because the small piston move much less fluid than the big piston does for the same amount of distance it moves, so the small piston must move much further (by the ratio of the areas) than the large piston.

Put things in SN, and use a reasonable number of SF.

2. You look at a bright white light reflected in a CD and surrounding it, you see rainbow colors.
   a) Explain why you see the rainbow of colors – you will likely need a drawing. In particular, which color is closest to the white light reflection and why?
   b) Make an estimate of the angles the light comes off at, and calculate the distance between the grooves on the CD, put your answer in lines per mm if you can.

Things have colors because the absorb the other colors, like why grass is green because chlorophyll absorbs red and blue. That's not what this is. All the light that is shined on the CD is reflected. Dispersion is when the index of refraction changes with frequency, so different colors refract at different angles when changing media… like a prism makes a rainbow. This is interference and diffraction. It is a different concept. Which is an atmospheric rainbow? Which is a CD rainbow?

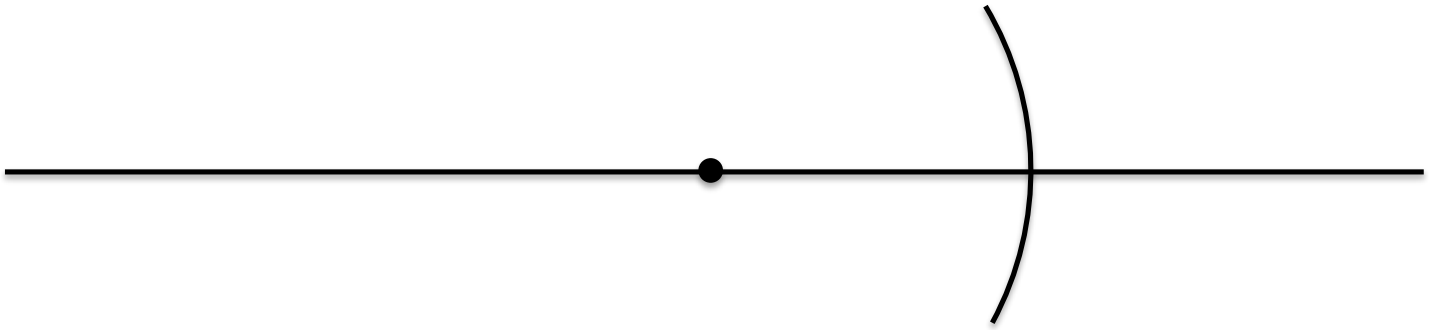
If blue comes off at about 30 degrees from the normal, we can make that important triangle to find that the distance between the grooves is $d = \frac{\lambda}{\sin(\theta)}$. So if blue light has a wavelength of ~ 450 nm, then the grooves are about 900 nm apart.

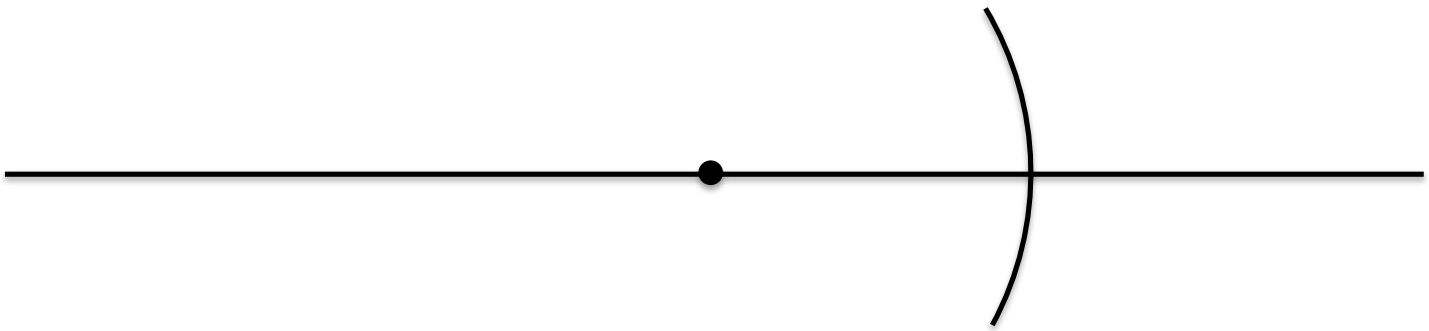
3. You see below a circular mirror of ***radius*** 20 cm, with the ***center of curvature*** shown as a dot. The mirror is reflective only on the ***left*** side. I put a 2 cm high toy 5 cm from the mirror's surface and position myself so I can see an image of the toy in the mirror.
   a) Please make a ray diagram to locate the image formed in the mirror's surface. *I put another diagram at the bottom in case you mess up the first one, but you don't have to use it.*
   b) Please circle the words that describe the image: (real, virtual, erect, inverted, enlarged, diminished)
   c) Please label the exact height of the image, and the distance of the image from the mirror's surface.
   d) Imagine you have a convex lens of focal length 20 cm. Where would you put this lens below such that you would get a diminished, real, image. Please put this lens into your drawing, and draw and label the resulting image.

You should get an image that is 4 cm high and 10 cm from the mirror's surface… but on the right side of the mirror… so you know it's a virtual image because the rays never cross… there's no actual light coming from the apparent source of light.

In order to get the second, real image, use the virtual image above as the new object for the convex lens. Remember that placement of the lens with respect to the object (virtual image) is very important to determine size of image. Where do you need to place the lens in order to ensure a diminished image?

People had real trouble using formulas. Just make two triangles, and use geometry. One triangle comes from drawing a line from the focus (half the distance of the radius of curvature) to the mirror. The other triangle comes from reflecting off the "post" (the point of the mirror on the central axis.) as if it were a straight mirror… remember tha tyou will need to extend these lines backwards.





4. You see below two light rays headed into an aquarium full of fresh water.
   a) Draw the light rays as they continue through the water and back out into the air, calculating and labeling the correct angles. I provided two diagrams in case you mess up the first one.
   b) Derive Snell's Law, which describes how the angle of light changes when transitioning between two different media.

1) Did you calculate the critical angle?
2) Can you ever have TIR when going from a light medium into a heavier medium?
3) Did you draw a perpendicular line to the surface at each intersection and identify the incident angle?