Name ______________________________________ **Student ID Number** _____________

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PHYS 107 Midterm #1

No phone/computer/internet usage is allowed. For multiple choice questions, please circle the best answer.

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1) When reading an accurate sundial, the key steps are:

A) The gnomon shadow will move in an arc from west to east across the sundial. From the position of the gnomon shadow on the sundial face determine the approximate time. From the length of the gnomon shadow determine the approximate date. Using the date and an analemma, correct for the earth's elliptical orbit to find the accurate local time. Finally, correct for distance of your sundial from the timezone center to get the time on your watch (UTC).

B) The gnomon shadow will move in an arc from east to west across the sundial. From the position of the gnomon shadow on the sundial face determine the local time. Finally, using an analemma determine the approximate timezone to get the time on your watch (UTC).

C) Like a clock hand, the gnomon shadow will move in a circle clockwise around the face of the sundial. From the time of sunrise determine the approximate date. Using an analemma, correct the sun's position to find the local time. Correct for offset from the timezone center to get the time on your watch (UTC).

D) Like a clock hand, the gnomon shadow will move in a circle clockwise around the face of the sundial. From the length of the gnomon shadow determine the approximate date. Using the date and an analemma, correct for changes in the earth's rotation to find the TAI time. Finally, correct for offset from the timezone center to get the time on your watch (UTC).

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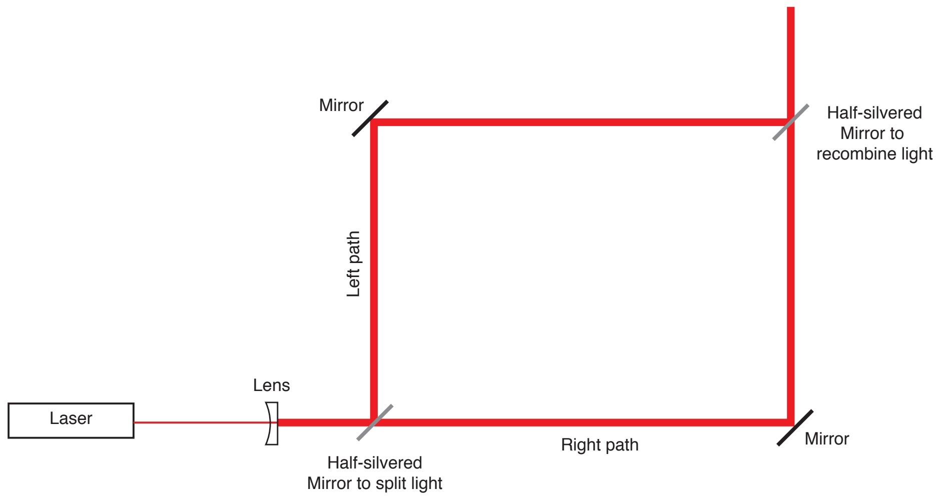
2) The below diagram shows the laser interferometer we studied in class. As I block various paths what do I see?



A) The stripes are created by bouncing off a slightly misaligned corner mirror, so only the light in the right path has stripes. So if we block the right path we see a smooth patch of light, but if we block the left path the stripes become clearer.

B) This works like the slits in aluminum foil, just bigger. If the light can travel the right path the laser dot is spread into a long solid streak of light (e.g. 1 slit). If I then allow light to also follow the left path I see stripes (e.g. 2 slits). If I block the right path I get back to the laser dot.

C) With both paths open I see stripes. If I block the right path the stripes disappear. Similarly if I block the left path the stripes disappear. I only get stripes if the particles of light can take both paths.

D) If I block the right path I see stripes. Similarly if I block the left path I see stripes. With both paths open the stripes disappear because the waves interfere.

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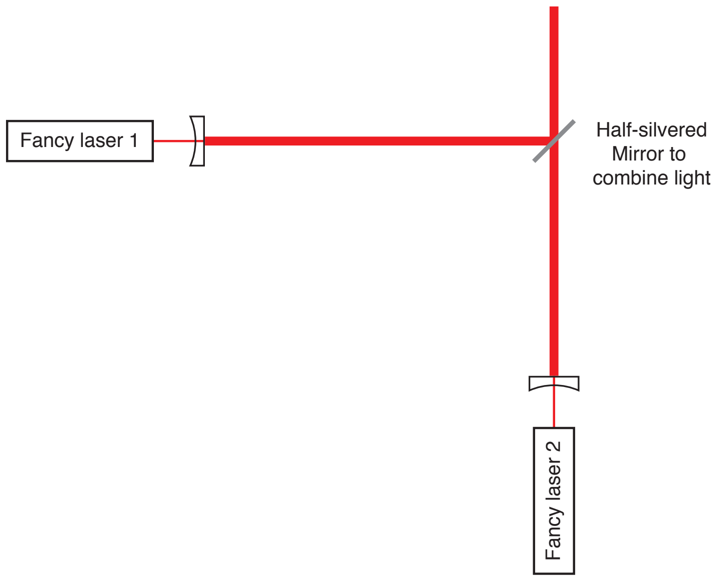
3) We now modify our interferometer so instead of splitting and recombining the light from one laser, we combine the beams from two precision lasers with identical color. Describe what we see:



A) Particles move as waves, so we see beats in time similar to the beating of two tuning forks.

B) Particles move as waves, so we see stripes just as we saw in problem 2 with both paths unblocked.

C) Particles move as waves, but because they are made in two different lasers the waves no longer mix and we see just a smooth patch of light

D) The particles are now independent, so we see a smooth pointillism painting.

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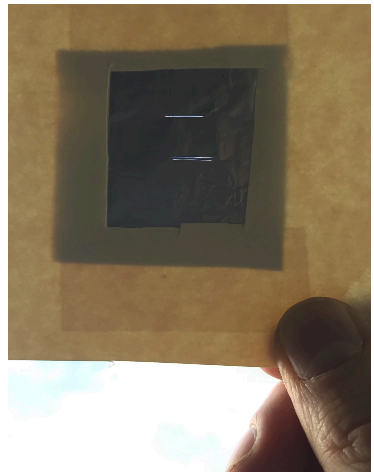
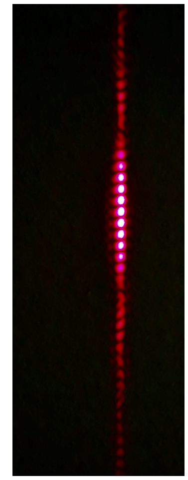
The photos to the right are from your homework assignment and show careful slits in tinfoil and the resulting light from a bright red laser passing through the two closely spaced slits. This diagram is used for both questions 4 & 5





4) I repeat the homework but with a very dim (low intensity) red laser, so dim that only one photon at a time is going through the slits. If I look at resulting pattern with a very sensitive camera, describe what I will see:

   A) A pointillism painting of stripes as each photon goes through. Each red photon will hit with the same strength, but I will see more photon hits where the stripes are bright and no hits where the stripes are dark.

   B) A pointillism painting of stripes as each photon goes through. I will see the same number of photon hits along the whole stripe, but they will hit harder where the stripes are bright and very softly where the stripes are dark.

   C) A pointillism painting, but with no stripes. Because I am sending one photon at a time through they cannot interfere with each other so the striping pattern goes away.

   D) A stripy smooth pattern that flashes. Each photon creates a stripey pattern, but because they are arriving one at a time the whole pattern flashes each time a photon arrives.

5) I again use a very dim laser emitting only one photon at a time, but this time I use a green laser instead of a red one. What do I see?

   A) A pointillism painting of stripes as each photon goes through, with the stripes being farther apart than when I used a red laser. I will see the same number of photon hits along the whole stripe, but they will hit harder where the stripes are bright and very softly where the stripes are dark.

   B) A pointillism painting of stripes as each photon goes through, with the stripes being closer together than when I used a red laser. Every green photon will hit harder than the red photons of the previous laser, and I will see more photon hits where the stripes are bright and no hits where the stripes are dark.

   C) A pointillism painting, but with no stripes. Because I am sending one photon at a time through they cannot interfere with each other so the striping pattern goes away. Every green photon will hit harder than the red photons of the previous laser.

   D) A stripy smooth pattern, with the stripes being farther apart than when I used a red laser. Because particles move like waves I get stripes, but the stripes must be smooth and individual photon hits cannot be seen.

6) How does GPS work?

A) Using an onboard atomic clock, a GPS satellite is used to give very accurate time to the cell phone towers which then repeat this time via radio flashes like metronomes. By timing the difference in arrival time of the signals from three or more cell phone towers your phone can determine its position.

B) Much like a geodimeter or LIDAR system, your phone bounces a beam of radio light off of 3 or more satellites. Since the speed of light is constant, by measuring how long the light takes to travel to each satellite and back your phone can determine distance to each satellite and thus its position.

C) Using onboard atomic clocks, each of the GPS satellites broadcast the time in radio light. Your phone can compare when it sees the radio ticks from each satellite to determine the time delay. Since the speed of light is constant, the time delays can be used to determine distance to each satellite and thus the position of your phone.

D) Your phone sends a radio message to the GPS satellite. The satellite can see the direction of the signal and the time delay compared to its onboard atomic clock, and radios back the location of your phone. Repeating with more satellites can improve the precision.

7) Imagine the zoom class of the distant future where one of the students is on earth and the other is traveling at high speed on a spaceship. Which of the following statements accurately describes what they experience?

A) They both agree on the speed of light. They disagree on time: both think time is running slowly for the other student. They also disagree on whether distant events like supernovae happen simultaneously.

B) They both agree on the speed of light. The do not see time as passing at the same rate, but agree it is moving more slowly for the student on the fast spaceship. The agree on whether distant events like supernovae happen simultaneously.

C) Because they both have light clocks, they agree on the passage of time. They disagree on the speed of light, and disagree on whether distant events like supernovae happen simultaneously.

D) Because of relativity, they can agree on the speed of light, the passage of time, and whether distant events like supernovae happen simultaneously.

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Essay Question

Describe how ship navigators and astronomers used Harrison's marine chronometer to solve the longitude problem. Make sure to describe the entire process, including how to determine both latitude (north-south) and longitude (east-west). You will be graded on both the accuracy and clarity of your answer.