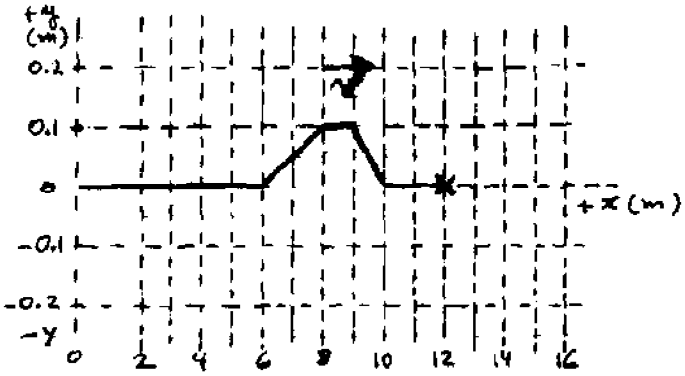
Corrected as done in exam date

PHYSICS 116, WINTER 2006, FINAL EXAM, O. E. VILCHES

This final exam consists of various problems written as 30 multiple choice questions. Please use a standard scanning sheet and fill the bubbles carefully. Remember to write your name correctly, as well as your student number, in letters/numbers and in bubbles. This class is PHYS 116, the exam is called FINAL, and my last name is VILCHES (just in case you don't remember!). Each multiple choice question is worth 5 points, for a total of 150 points. No penalty for wrong answer.

The first three questions refer to the following statement and picture. An asymmetric pulse in a rope of mass per unit length M/L and under tension T moves in the positive x-direction at 1 m/s. Notice the different x and y scales (pulse is exaggerated).. The picture shows the pulse at t = 0 s. Point X is a mark at the essentially free end of the rope.



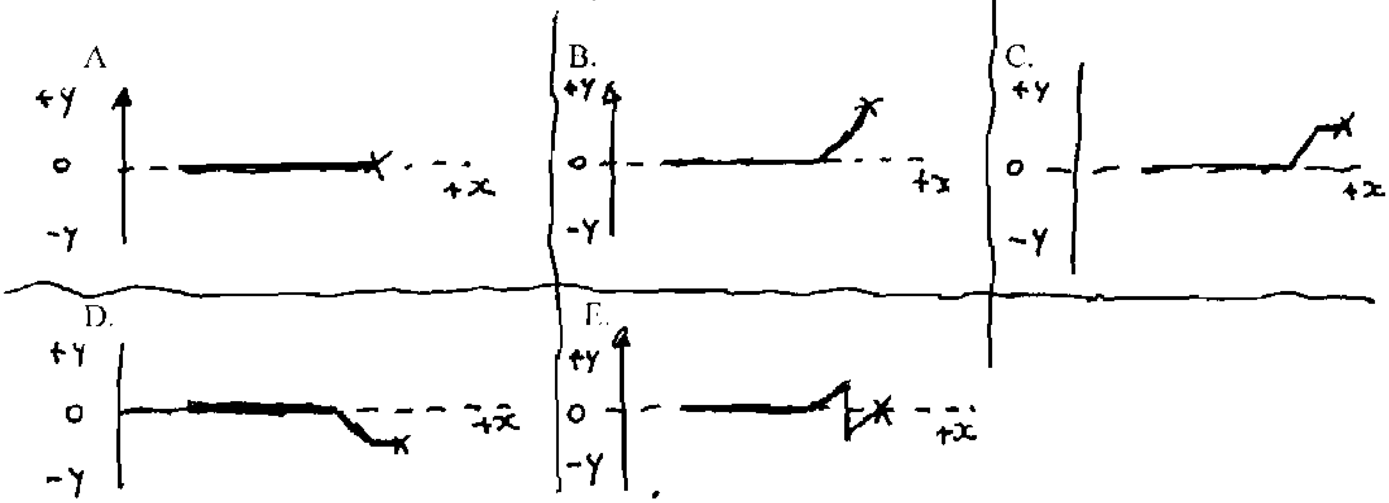
Question 1. The maximum speed at which Point X will move in the x-direction is:

A. 0.1 m/s B. 0.2 m/s C. 0 m/s D. 1 m/s E. 2 m/s

Question 2. The maximum speed at which Point X will move in the **y**-direction is:

A. 0.1 m/s B. 0.2 m/s C. 0 m/s D. 1 m/s E. 2 m/s

Question 3. At time t = 3 seconds the pulse will look like one of the pictures.



<u>The next three questions refer to this statement.</u> An L = 4 meters long organ pipe is open at both ends, see sketch on margin. Superman plays it! Assume that the speed of sound on Earth is 340 m/s

Question 4. When played on Earth, the frequency of the third overtone (4^{th} harmonic) is:

A. 42.5 Hz B. 85 Hz C. [redacted]85 Hz D. 170 Hz E. 340 Hz

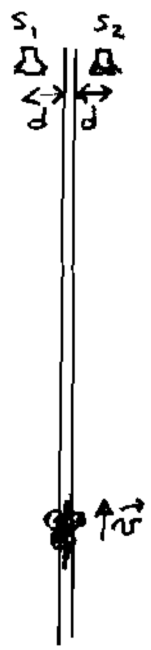
Question 5. Superman takes the pipe to Planet Krypton where he plays it again. The speed of sound in Kr is 100 m/s. The fundamental frequency, when played in Kr, is now:

A. Same as on Earth since length of pipe has not changed
B. Higher than on Earth since speed of sound has decreased
C. Lower than on Earth since speed of sound has decreased
D. Same as on Earth since the wavelength of the fundamental has not changed
E. Same as on Earth since Superman has not changed

Question 6. When Superman's Child blows on the pipe he can produce sound that at some distance $\mathcal{L}$ has an intensity of 10^{-6} Watts/m^2. When Superman blows on the same pipe he can produce sound that at the same distance $\mathcal{L}$ has an intensity 20 db higher. The actual intensity heard at a distance $\mathcal{L}$ when Superman blows is then:

A. 20 W/m^2 B. 200 W/m^2 C. 20 x 10^{-6} W/m^2 D. 10^{-5} W/m^2 E. 10^{-4} W/m^2

<u>The next two questions refer to this statement.</u> A bicycle rider moves along a straight road towards two speakers placed perpendicular to the road and at equal distances from it. The speakers emit sound of a single frequency, f_0, with the same phase, and [redacted] each one with the same intensity I_0, see margin for sketch.



Question 7. The rider hears:

A. Sound with intensity "beats"
B. Sound with constructive and destructive interference depending on where he is.
C. Sound of uniform intensity at frequency $f < f_0$
D. Sound of uniform intensity at frequency $f = f_0$
E. Sound of uniform intensity at frequency $f > f_0$

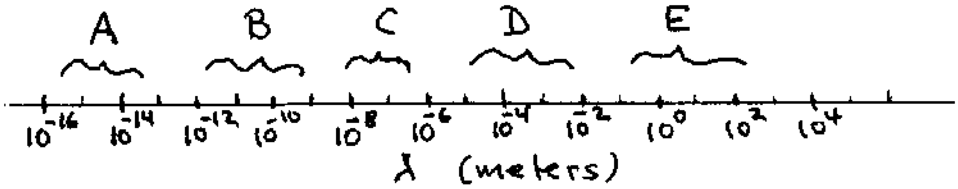
Question 8. The average intensity of the sound heard by the rider is:

A. $2I_0$ B. $4I_0$ C. $I_0 \sin 2\pi f t$ D. $2I_0 \sin 2\pi f t$ E. $4I_0 \sin 2\pi f t$

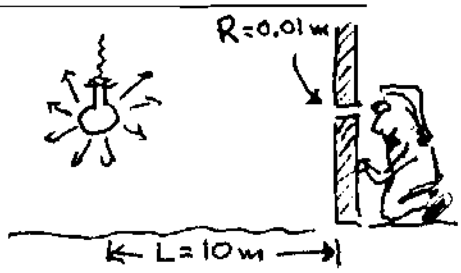
Question 9. One of the following statements **is not true**.

A. The kinetic energy of photons is given by (½) m c^2
B. Sound waves can not be polarized
C. The total energy emitted by a black body is proportional to T^4
D. Energy levels of the Chlorine atom are quantized
E. Electromagnetic waves can be polarized

Question 10. When you use a microwave oven, the wavelength of the electromagnetic radiation is likely to be (choose one of the letters in the logarithmic graphs below).



The following three questions refer to this statement/problem.



Peeking through a small hole of radius R = 0.01 m a person sees a P = 100 Watts yellow light bulb (λ = 500 nm) emitting energy uniformly in all directions. The bulb is at a distance L = 10 m from the hole. (P means AVERAGE Power)

Question 11. The energy per unit time going through the small hole is:

A. 4×10^8 W B. 1×10^8 W C. 3.2×10^5 W D. 7.96×10^{-6} W E. 2.5×10^{-5} W

Question 12. The amplitude of the electric field wave going through the small hole is:

A. $[2P/4\pi L^2 c\varepsilon_0]^{1/2}$ B. $[P/4\pi L^2 c\varepsilon_0]^{1/2}$ C. $[2P/\pi R^2 c\varepsilon_0]^{1/2}$ D. $[P/\pi R^2 c\varepsilon_0]^{1/2}$ E. $[2P/c\varepsilon_0]^{1/2}$

Question 13. Imagine that the correct answer to Question 11 was 1×10^{-4} Watts. Then, the number of photons going through the small hole per second is, approximately:

A. 4×10^{-15} 1/s B. 2.5×10^{14} 1/s C. 100 1/s D. 4×10^8 1/s E. 3.2×10^5 1/s

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The next two questions refer to the same statement/problem.

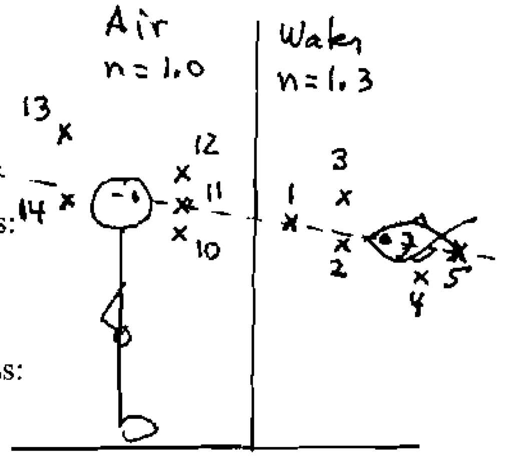
A person and a fish in a tank ($n_{water} = 1.3$) see "eye to eye". Assume $n_{air} = 1$.

Question 14. The person [redacted] sees the eye of the fish [redacted] at about little cross:

A. 1 B. 2 C. 3 D. 4 E. 5

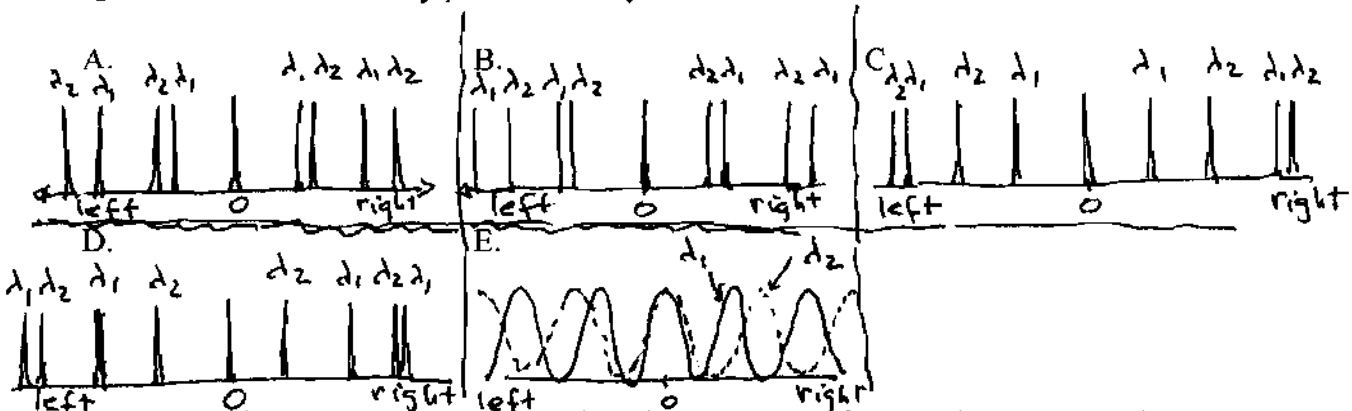
Question 15. The fish [redacted] sees the eye of the person [redacted] at about little cross:

A. 10 B. 11 C. 12 D. 13 E. 14



The next three questions refer to this statement. For a lecture demo diffraction gratings are distributed to the class. The gratings have N =100 perfect slits, with the separation between two neighbor slits being 2000 nm. The slits are used to view an atomic source of light which emits at two wavelengths, $\lambda_1 = 500$ nm and $\lambda_2 = 600$ nm.

Question 16. The intensity pattern seen by the students will look like:



Question 17. How many complete orders (both wavelengths) are visible in one direction for angles between 0 and 90^0 (include 90^0, if necessary)?

A. 2 B. 3 C. 4 D. 5 E. 6

Question 18. The width of the central maximum for either one of the wavelengths is given by $\sin\theta = \lambda/100d$, which makes it very narrow. This narrow angle is determined by:

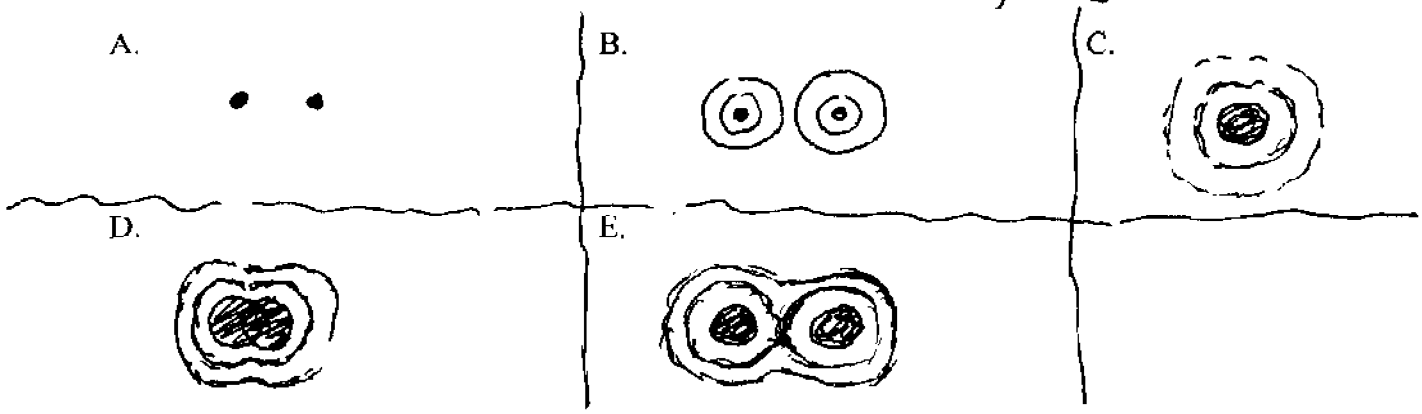
A. The width of the individual slits being very small
B. There are two wavelengths going through the slits
C. The electric field of the light transmitted
D. A phase difference of half a wavelength between the first and 100th slit.
E. A phase difference of half a wavelength between the first and 50th slit.

The next two questions are related. The resolution of the human eye at night (pupil fully dilated) for 500 nm wavelength light is such that it can see two objects that are 1.2 meters apart as separate objects when they are 10 km away from the eyes.

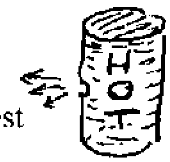
Question 19. At maximum resolution the distance between the images formed in the retina of the eye, for a normal "spherical" eye of 2 cm diameter is then approximately:

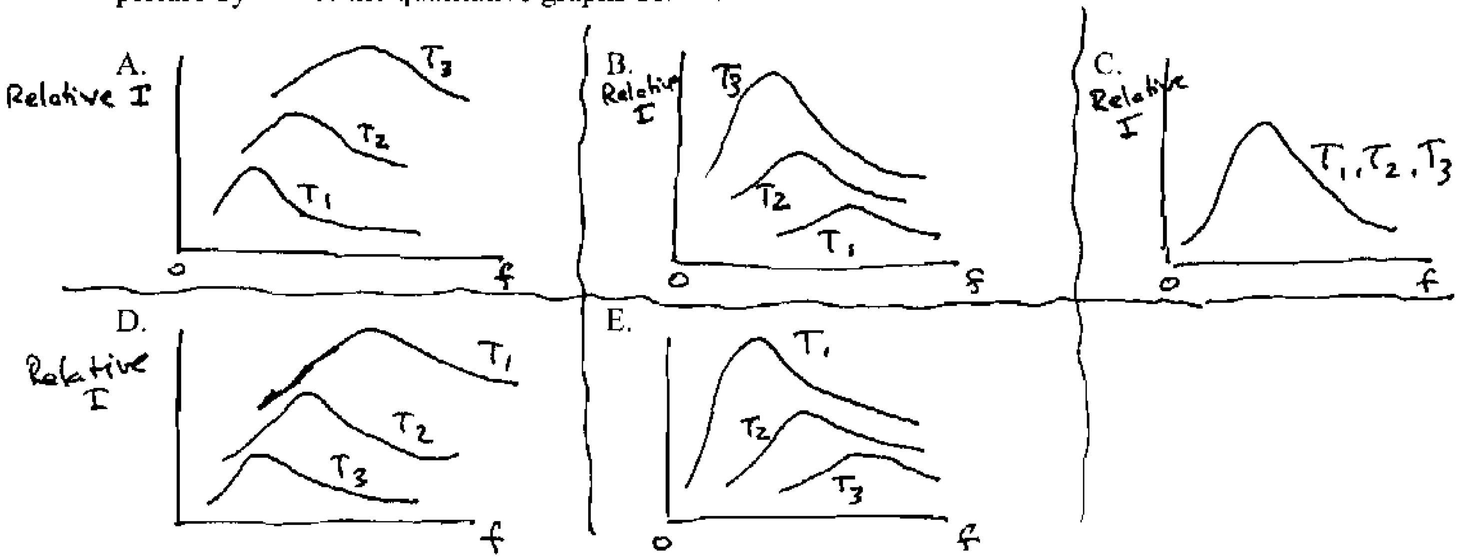
A. 2.4×10^{-8} m B. 2.4×10^{-6} m C. 2.4×10^{-4} m D. 2.4×10^{-2} m E. 2.0×10^{-2}

Question 20. At maximum resolution, the image formed on the retina of "two car lights" 10 km away should look like: [dark in picture is actually "bright" !]



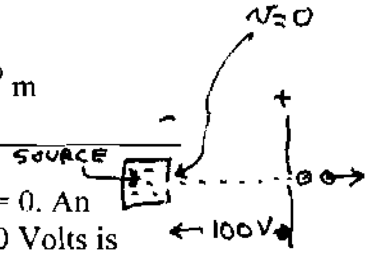
Question 21. A cylindrical cavity with a small hole on its walls lets a small amount of radiation escape. The cavity is heated to three different temperatures, such that $T_1 < T_2 < T_3$. The intensity of radiation per unit frequency coming out of the cavity is best picture by one of the qualitative graphs below:





Question 22. The Sun has a surface temperature of 6000K. A black body is cooled to 3K. The wavelength at the peak of the emitted radiation from the 3K body should be in the range of:

A. 1000 m B. 1 m C. 10^{-3} m D. 10^{-6} m E. 10^{-9} m

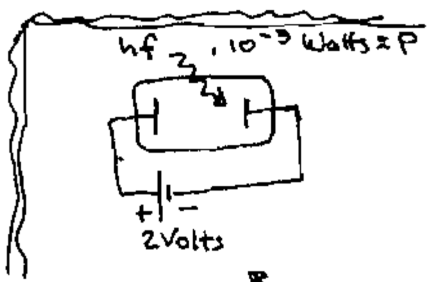


Question 23. A "source" produces electrons at rest (v =0 m/s) at position x = 0. An electric field exists in the +x direction, such that a potential difference of 100 Volts is created as per sketch. Electrons coming through the small hole at position x = 1 cm will have an energy

A. 100 Joules B. 100 eV C. 1.6×10^{-19}J D. 1.6×10^{-19}eV E. 160×10^{-19}eV

Question 24. Imagine you have an electron, a neutron, and a photon all with the same energy of 100 eV. Their de Broglie's wavelengths are in the rank:

A. $\lambda_N > \lambda_E > \lambda_P$
B. $\lambda_N = \lambda_E = \lambda_P$
C. $\lambda_N < \lambda_E < \lambda_P$
D. $\lambda_N = \lambda_E > \lambda_P$
E. $\lambda_N = \lambda_E < \lambda_P$



Question 25. A 10^{-3} Watts laser emits radiation of a single wavelength. The radiation is used to emit electrons from a metal electrode, connected to a battery as shown in the picture. The battery provides a potential difference of 2 Volts, which is the minimum potential difference needed to stop all the electrons emitted from the metal surface. The work function of the metal is W_0 = 3 eV. The wavelength of the laser radiation is:

A. 3731 nm B. 2488 nm C. 622 nm D. 415 nm E. 249 nm

Lithium (Li)

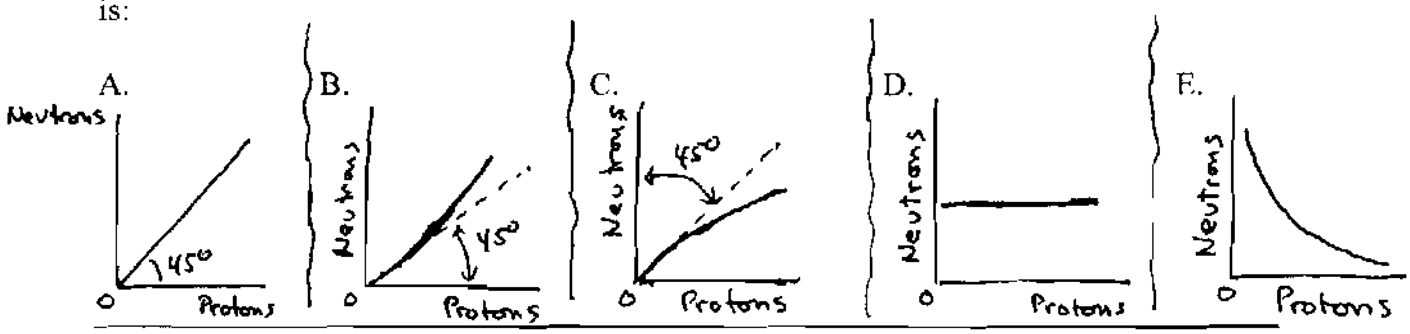
Question 26. The third element in the periodic table is [redacted]. The reason why its outermost electron (the valence electron) is in the n = 2, ℓ= 0, m_ℓ= 0, s = -1/2 energy state is:

A. This state is an excited state
B. Two electrons in Be can not have the same set of identical quantum numbers
C. Bohr atom solution gives this set of quantum numbers
D. The energy in the lowest energy states is proportional to $1/n^2$
E. The orbits of electrons have a radius proportional to n^2

Question 27. Imagine that only one electron is attached to a $_{30}$Zn (Zinc) nucleus. This "atom" looks like a hydrogen atom but with a nuclear charge of +Ze. The Bohr model energy levels for the electron in this "atom" are given by $E_n = -13.6\ Z^2/n^2$ eV. The shortest wavelength photon emitted by this "atom" will have energy of:

A. 13.6 eV B. 306 eV C. 408 eV D. 9180 eV E. 12240 eV

Question 28. The nuclei of atoms have two components: neutrons and protons. The graph that best describes how the number of neutrons grows as a function of increasing Z is:



The last two questions are about the same theme but are not interconnected.

Question 29. The radioactive decay scheme of ^{214}Po is shown [redacted] below
To go from ^{214}Po to ^{206}Pb the sequence of particles emitted as radiation is:

A. α, β, β, α B. β, α, α, β C. β, α, β, α D. α, γ, γ, α E. α, β, α, β

Question 30. ^{210}Po has a half life of 140 days. A small sample of this substance produced 100 radioactive decays per day at time t = 0. After 70 days, the count rate will be a fraction of the initial counting rate. This fraction is about:

A. 10% B. 20% C. 30% D. 50% E. 70%