Exam 5 – white version

Physics 2760

FS 2008

Last Name_____

First Name_____

ID # _____

Solutions

This is a closed book exam. I understand, pursuant to University Regulations on academic honesty, that I am not to use any notes or information other than what is in the official, non-annotated formula sheet.

Signature_____

For multiple choice questions, please make sure that you circle the letter for the answer which you believe to be correct and only that answer. If more than one answer is circled for the same problem, you will not receive credit for it. Don't get hung up on questions. They should take only one or two minutes each. If you find yourself spending more than a few minutes on a multiple choice question you are probably looking at it the wrong way. You should skip it for now and come back to it later.

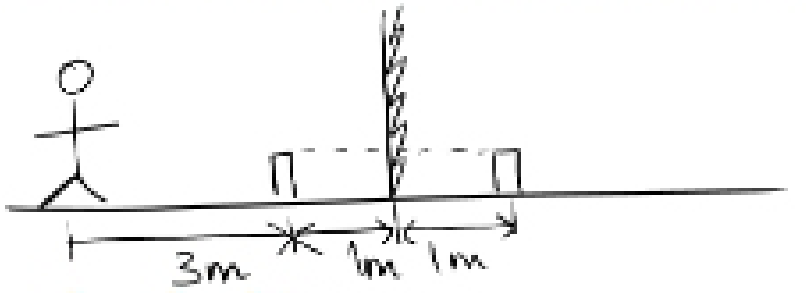
For full credit show your work for solutions to questions that require calculations. Explain from where you start to solve the problem and show your math flowing from it for full credit. **No shown work, no credit!**

Relax, read carefully, think – and then read everything again.

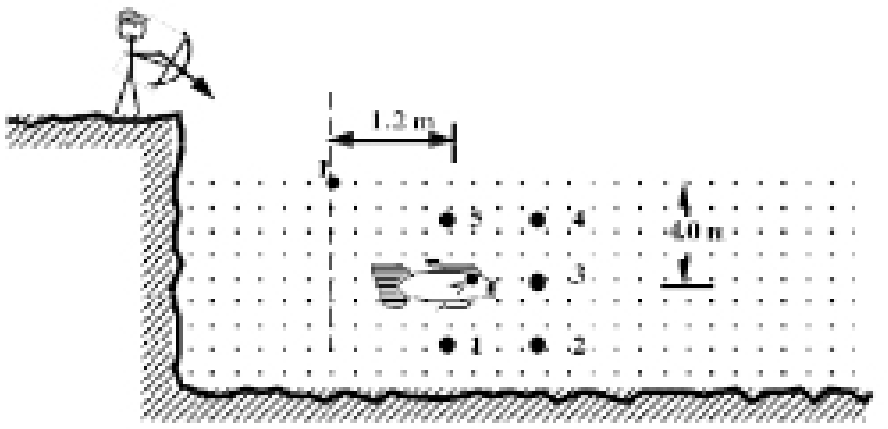
During the exam, if you have questions please raise your hand and the TA or the instructor will come to you and provide help.

1. An object is placed 1 m in front of a plane mirror. An observer stands 3 m behind the object. For what distance must the observer focus his eyes in order to see the image of the object?

a) 1 m
b) 2 m
c) 3 m
d) 4 m
e) 5 m



A fish swims 4.0 m below the surface of a still lake as shown in the figure. When an archer attempts to shoot the fish, the arrow enters the water at point P that is a horizontal distance 1.2 m from the fish.



2. At which of the numbered positions should the archer aim to hit the fish?

a) 1
b) 2
c) 3
d) 4
e) 5

3. Which one of the following phrases most accurately describes the image of the fish as seen by the archer?

a) real and inverted
b) virtual and inverted
c) real and reversed right to left
d) virtual with its orientation unaltered
e) real with its orientation unaltered

4. A double slit is illuminated with monochromatic light of wavelength 6.00×10^{2} nm. The $m = 0$ and $m = 1$ bright fringes are separated by 3.0 cm on a screen which is located 4.0 m from the slits. What is the separation between the slits?

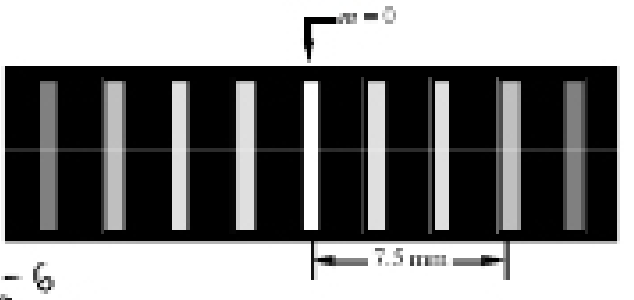
a) 4.0×10^{-5} m
b) 8.0×10^{-5} m
c) 1.2×10^{-4} m
d) 1.6×10^{-4} m
e) 2.4×10^{-4} m

$$\Delta y = \frac{\lambda L}{a}$$

$$a = \frac{\lambda L}{\Delta y} = \frac{6 \times 10^{-7} \times 4}{3 \times 10^{-2}} = 8 \times 10^{-5}$$

5. Light is incident on two slits that are separated by 0.2 mm. The figure shows the resulting interference pattern observed on a screen 1.0 m from the slits. Determine the wavelength of light used in this experiment.

a) 0.05 nm
b) 0.50 nm
c) 50 nm
d) 500 nm
e) 5000 nm



$y_3 = 7.5$ mm

$$y_3 = 3 \cdot \frac{\lambda L}{a} \Rightarrow \lambda = \frac{a \cdot y_3}{3L}$$

$$\lambda = \frac{0.2 \times 10^{-3} \cdot 7.5 \times 10^{-3}}{3 \cdot 1} = 0.5 \times 10^{-6} \text{ m}$$

6. Light from a red laser passes through a single slit to form a diffraction pattern. If the width of the slit is increased by a factor of two, what happens to the width of the central maximum?

Note: *Assume that the angle θ is sufficiently small so that* (sin θ) *is nearly equal to* θ.

a) The width of the central maximum increases by a factor of 4.
b) The width of the central maximum decreases by a factor of 2.
c) The width of the central maximum decreases by a factor of 4.
d) The width of the central maximum increases by a factor of 2.
e) The width of the central maximum does not change.

7. A diffraction grating that has 4500 lines/cm is illuminated by light that has a single wavelength. If a second order maximum is observed at an angle of 42° with respect to the central maximum, what is the wavelength of this light?
   a) 1500 nm
   b) 930 nm
   c) 740 nm
   d) 370 nm
   e) 1100 nm

$d \sin\theta_2 = 2\cdot\lambda$ where $d = \frac{1}{4500}$ cm

$\lambda = \frac{d \sin\theta_2}{2} = \frac{\sin 42^\circ}{2\cdot 4500} = 7.4\times10^{-5}$ cm

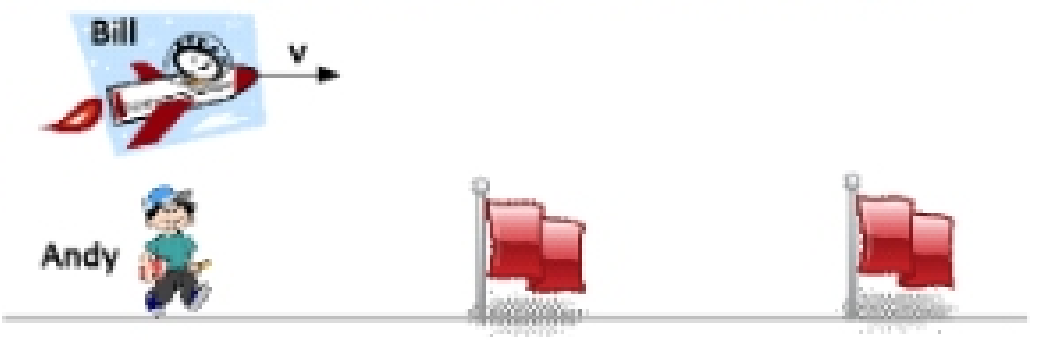
8. Determine the speed at which the kinetic energy of an electron is equal to twice its rest energy.
   a) 0.45c
   b) 0.87c
   c) 0.99c
   d) 0.63c
   e) 0.94c

$K = 2mc^2 \Rightarrow K = E - mc^2 \Rightarrow 2mc^2 = E - mc^2$

$\Rightarrow E = 3mc^2 \Rightarrow \frac{mc^2}{\sqrt{1-v^2/c^2}} = 3mc^2 \Rightarrow \frac{1}{1-v^2/c^2} = 9$

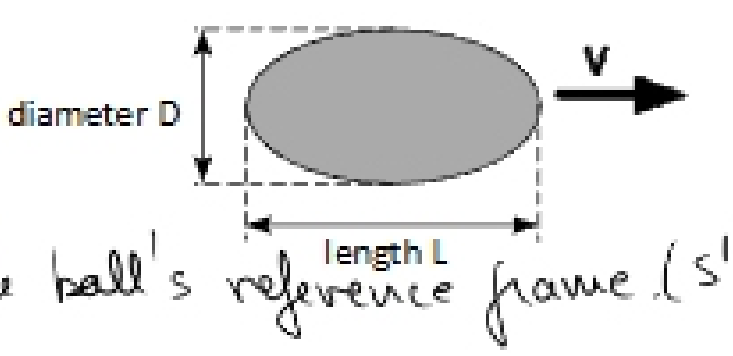
$\frac{1}{9} = 1 - \frac{v^2}{c^2} \Rightarrow v^2 = \frac{8c^2}{9} \Rightarrow v \simeq 0.94c$

9. Two friends, Andy and Bill, conduct the following experiment: While Andy watches from the ground, Bill flies past Andy in a rocket ship, moving at a high speed v. There are two flagpoles located along the path of Bill. Both Andy and Bill measure the distance between the flagpoles and the time it takes Bill to fly from one pole to the other. Considering the results each obtains from his own measurements, whose measurement gives the proper distance between the poles, and who measures the proper value of the time it takes Bill to fly from one pole to the other?



   a) Bill measures both the proper time and the proper distance
   b) Andy measures both the proper time and the proper distance
   c) Bill measures the proper time and Andy measures the proper distance
   d) Andy measures the proper time and Bill measures the proper distance
   e) Andy measures the proper distance but neither measures the proper time

10. Daniel Chase throws a football in a tight spiral across the field towards the goal. Assume the length of a football, L, is twice its fattest diameter, D. How fast does he have to throw the football so that it will seem a perfect sphere (L = D in this case) to his coach sitting on the sideline? Express your answer in terms of c, the velocity of light.
   a) v = 0.866 c
   b) v = 0.71 c
   c) v = 0.5 c
   d) v = 1.73 c
   e) v = 1.0 c



L_{proper} is measured in the ball's reference frame (S')

S → L = D

S' → L = 2D = L_{proper}.

$L = L_{proper}\sqrt{1-v^2/c^2} \Rightarrow D = 2D\sqrt{1-v^2/c^2} \Rightarrow \sqrt{1-v^2/c^2} = \frac{1}{2}$

$1 - v^2/c^2 = \frac{1}{4} \Rightarrow v^2 = \frac{3c^2}{4} \Rightarrow v = 0.86c$

11. What will you most likely do during winter vacation?
   a) sleep very late
   b) watch a lot of TV
   c) forget all the physics I have learned
   d) all of the above