PHYS130

# Physics 130
# Optics, Wave Motion and Sound
## Final Examination
**7 December, 2007**
**2:00 PM – 5:00 PM Main Gym**

All Sections (Consolidated) Course Convenor: Dr Jan Jung

**NAME:**_____ **ID #** _____

A single 8 1/2" x 11" formula sheet is permitted.
Calculators without communications features are permitted. All other electronic devices are prohibited.
The exam is 3 hours (180 minutes) in length.
Attempt ALL questions.
Answers must be clearly indicated on the answer sheet using an HB pencil.
Use the provided exam booklets for rough work. (You may write on this exam paper).
At the end of the exam, turn in this exam paper, your answer sheet, your formula sheet and the exam booklet(s). Enclose all in the exam booklet, and turn everything in to the box for your section.

**ON THE ANSWER SHEET ENTER:**
**Your Name (Surname followed by space then given names)**
**Student Identification Number**

**Course Section in Special Codes:**

| Section | Instructor | Lecture Time | Code |
|---|---|---|---|
| A01 | Akbar | 09:00 – 09:50 AM | J = 1 |
| A02 | Khan | 10:00 – 10:50 AM | J = 2 |
| A03 | Jung | 02:00 – 02:50 PM | J = 3 |
| A04 | Lawrie | 03:00 – 03:50 PM | J = 4 |

Grading:
2 choice questions: 2 points for correct answer, no partial credit
3 choice questions: 3 points for correct answer, no partial credit
5 choice questions: 5 points for the correct answer if no other answers selected
3 points if 2 answers selected, one of which is correct.
1 point if 3 answers selected, one of which is correct.

**There is only one correct answer to each question. If you believe the correct answer is not listed, please ask, then if that does not help, choose the closest matching value.**

**There are 11 pages with 37 questions for a maximum total of 139 points for this exam.**

IF ANYTHING IS UNCLEAR, PLEASE ASK!

1. The potential and kinetic energies of an object undergoing simple motion are equal when the object has a displacement $|y| = \frac{A}{2}$ (A is the amplitude of motion).

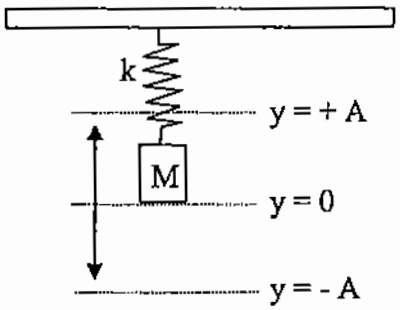
   A. True
   B. False

2. A mass is suspended from an ideal spring. When at rest (at the equilibrium position), it is observed that the spring is stretched 20.0 cm from its un-stretched length. The mass is then set into motion, and undergoes oscillations having a frequency of: (Use $g = 9.81\ m/s^2$, if needed.)

   A. 0.897 Hz
   B. 1.11 Hz
   C. 8.09 Hz

***The next 2 questions refer to the following situation:***

A block of mass M is attached to an ideal vertical spring (spring constant k) and can undergo simple harmonic motion about an equilibrium position y = 0. The period of oscillation of the block is 10.0 seconds.




3. Starting from rest at y = - 10.0 cm, how much time does it take the mass to travel a total distance of 100.0 cm?

   A. 25.0 seconds
   B. 50.0 seconds
   C. 100.0 seconds

4. Given this same mass, the motion is stopped and then restarted with different initial conditions. It is observed that at t = 0 sec, the displacement is y = 3.75 cm, the velocity is – 4.08 cm/s and the acceleration is – 1.48 $cm/s^2$. Which one of the following best describes the displacement as a function of time?

   A. $y(t) = (7.50\ cm)\mathrm{Cos}\left[(7/5)t + 1.047\right]$
   B. $y(t) = (7.50\ cm)\mathrm{Sin}\left[(7/5)t + 1.047\right]$
   C. $y(t) = (7.50\ cm)\mathrm{Cos}\left[(7/5)t - 1.047\right]$
   D. $y(t) = (3.75\ cm)\mathrm{Cos}\left[(7/5)t + 1.047\right]$
   E. $y(t) = (3.75\ cm)\mathrm{Sin}\left[(7/5)t + 1.047\right]$

5. Two simple pendulums have the same mass, but are suspended by thin cords (otherwise identical) of different lengths. The two pendulums will therefore undergo small amplitude oscillations with the same angular frequency.

   A. True
   B. False

6. Which one of the following functions, satisfies the wave equation, $\frac{\partial^2 y(x,t)}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y(x,t)}{\partial t^2}$, where $v = \frac{\omega}{k}$ and y is the displacement?

   A. $y(x,t) = A[\cos(kx) + \cos(\omega t)]$
   B. $y(x,t) = A\cos(kx + \omega t)$

7. The frequency of sound observed by a person moving towards a stationary sound source is 9.5 % higher than the frequency emitted by the source. If the speed of sound in air for this situation is 340 m/s, what is the speed of the moving person?

   A. 23 m/s
   B. 29 m/s
   C. 32 m/s
   D. 92 m/s
   E. 310 m/s

8. The sound intensity level for normal conversation (one person speaking) is 65 dB. What is the resulting sound intensity level if two people are speaking simultaneously? *(If needed, the reference sound intensity is $I_o = 10^{-12}$ W/m$^2$)*

   A. 68 dB
   B. 75 dB
   C. 130 dB

9. An out of tune guitar produces a beat frequency when compared to a standard 256 Hz tuning fork. At a particular tension, F, the beat frequency is 1.5 Hz. The beat frequency decreases if the string tension is increased. How much should the tension be changed to make the guitar string frequency (fundamental mode) equal to 256 Hz?

   A. Increase F by 0.59 %
   B. Increase F by 1.2 %
   C. Decrease F by 0.59 %
   D. Decrease F by 1.2 %
   E. Impossible to say without knowing the mass per unit length or the tension.

***The next three questions refer to the following situation:***

A simple harmonic oscillator located at the point x = 0 generates transverse travelling waves on a long string along the x-axis *(The string extends from $x = -\infty$ to $x = +\infty$, so there are no reflections from the far ends).* The oscillator operates at a frequency of 120 Hz, with an amplitude of 5.00 mm. The string has a linear mass density of 1.00 g/m and is stretched with a tension of 75.0 N.

10. Find the speed of the generated waves.

    A. 274 m/s
    B. 8.66 m/s
    C. 3.77 m/s

11. Find the maximum transverse acceleration of any point on the string.

    A. 3.77 $m/s^2$
    B. 2840 $m/s^2$
    C. 3770 $m/s^2$

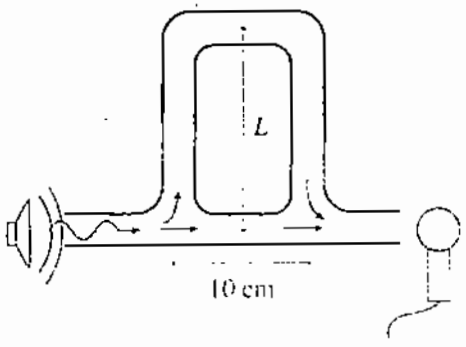
12. Find the average power that must be supplied per cycle by the oscillator to generate these waves. *(Note that the waves propagate in both the positive and negative x directions, away from the source)*

    A. 20.5 kW
    B. 566 W
    C. 283 W
    D. 3.89 W
    E. 1.95 W

13. Sound of frequency *f* is broadcast into the enclosed tube, shown below, which is filled with room-temperature air. The upper section, of height *L*, can be extended like a trombone slide to vary the distance L. Due to interference between the two possible paths, a microphone at the far end of the tube detects minima of the sound intensity when *L* is 17.5 cm, 32.5 cm, and 47.5 cm, and at no positions in between. *(The speed of sound in air for this situation is 340 m/s, if needed).*

    Given this information, what is the wavelength of the sound used?

    A. 8.75 cm
    B. 15.0 cm
    C. 17.5 cm
    D. 30.0 cm
    E. 35.0 cm



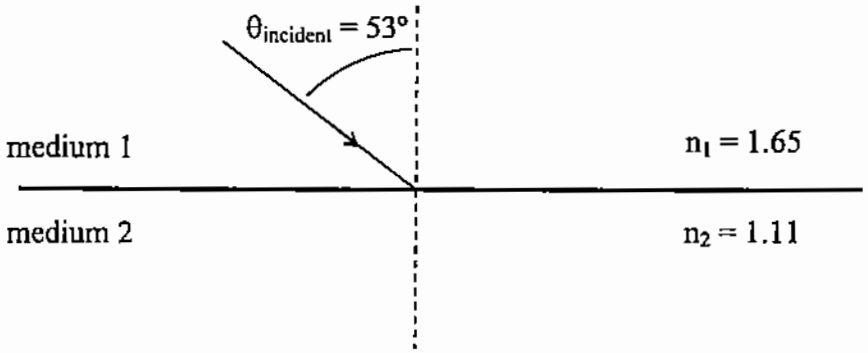
14. When a beam of monochromatic light travels from a medium with index of refraction $n_1$ to a medium with index of refraction $n_2$ ($n_1 > n_2$), the frequency of light remains the same.

A. True
B. False

15. If a real object is placed between the focal point and the vertex of a concave mirror, the image formed is:

A. real and upright.
B. real and inverted.
C. virtual and upright.
D. virtual and inverted.
E. impossible to say, need to know the radius of curvature.

16. A light ray is incident on the surface dividing medium 1 and medium 2 as shown in the diagram below. Find the angle of the outgoing ray(s) relative to the normal.




A. There will be 2 outgoing rays, one at 32° in medium 1, and the other at 48° in medium 2
B. There will be 2 outgoing rays, one at 53° in medium 1, and the other at 37° in medium 2
C. There will be 2 outgoing rays, one at 53° in medium 1, and the other at 42° in medium 2
D. There will be only one outgoing ray, at 42° in medium 1.
E. There will be only one outgoing ray, at 53° in medium 1.

17. A single convex spherical mirror can produce a real or a virtual image depending on if the object is to the right or left of the focal point of the mirror.

A. True
B. False

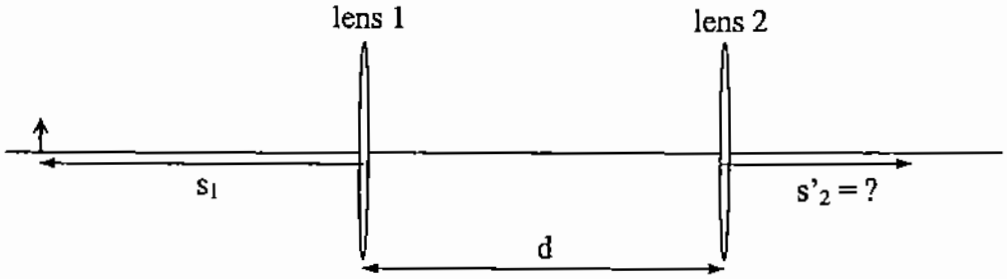
18. A beam of light is incident on the interface between medium A ($n_A$) and medium B ($n_B$). The light gets partially reflected and partially refracted. The refracted (NOT the reflected) part:

A. does not undergo a phase shift, regardless of the values of $n_A$ and $n_B$.
B. undergoes a phase shift of $\pi$ if $n_A > n_B$.
C. undergoes a phase shift of $\pi$ if $n_A < n_B$.

19. The condition for constructive interference of light (vacuum wavelength $\lambda_o$) being reflected (in air) from a thin oil film (thickness t and index of refraction $n_{oil}$) floating on water ($n_{air} < n_{oil} < n_{water}$) is:

A. $2t = m\lambda_o$
B. $2t = (m+\frac{1}{2})\lambda_o$
C. $2t = m\left(\frac{\lambda_o}{n_{oil}}\right)$
D. $2t = (m+\frac{1}{2})\left(\frac{\lambda_o}{n_{oil}}\right)$
E. $2t = m\, n_{oil}\, \lambda_o$

20. Two converging lenses are arranged as shown in the picture. The focal lengths of the lenses are $f_1 = 17.0$ cm and $f_2 = 5.00$ cm. The distance between the lenses, d, is 35 cm. If an object is placed distance $s_1 = 34$ cm from lens 1, at what distance, $s'_2$, is an imaged formed?

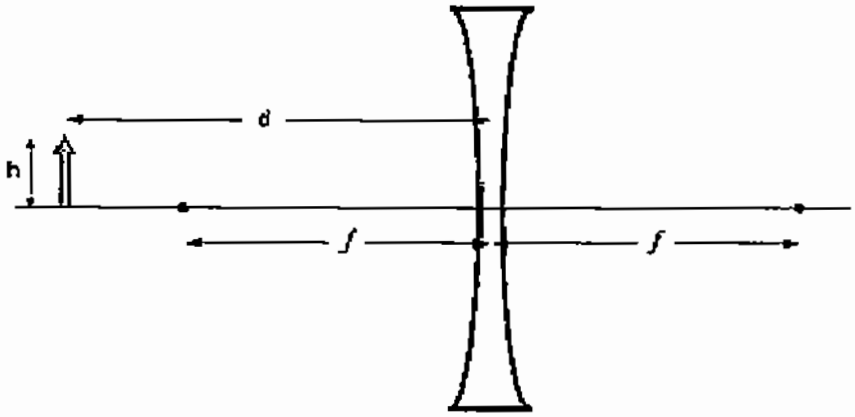



A. $s'_2 = -2.00$ cm
B. $s'_2 = -1.25$ cm
C. $s'_2 = -1.00$ cm
D. $s'_2 = +1.00$ cm
E. $s'_2 = +1.25$ cm

21. When viewed at normal incidence, a certain region of a soap bubble appears red ($\lambda = 632$ nm, in air) due to reflection. What is the smallest possible thickness of this region of the bubble? The index of refraction of the soap film is n = 1.36.

A. 79 nm
B. 116 nm
C. 158 nm
D. 232 nm
E. 316 nm

22. An object with height $h = 7.5$ cm lies a distance $d = 32$ cm before a diverging lens with focal length $f = -25$ cm.




What is the size of the image produced?

A. 25 cm
B. 17 cm
C. 6.6 cm
D. 3.3 cm
E. 2.2 cm

23. You've been asked to design a thin converging lens with a focal length of 18.0 cm. The glass to be used has an index of refraction n = 1.75, and is to be used in air (n =1). The lens is to be planoconvex (one flat side, one curved). What radius of curvature (magnitude) is required for the curved side?

A. 6.75 cm
B. 10.3 cm
C. 13.5 cm
D. 27.0 cm
E. 43.2 cm

24. The left end of a long glass rod has a convex hemispherical surface 2.50 cm in radius. The refractive index of the glass is 1.60. What would be the position of the image if an object is placed in air on the axis of the rod a large distance (effectively infinitely far) from the curved end?

A. On the left of the vertex
B. On the right of the vertex
C. Indeterminable

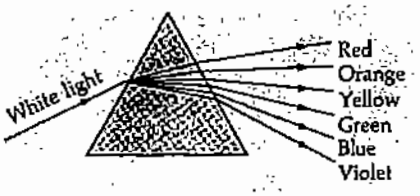
25. Coherent light from a sodium-vapour lamp is passed through a filter that blocks all light except for light of a single particular wavelength. The light then falls on two slits separated by 0.450 mm. In the resulting interference pattern on a screen 2.50 m away, adjacent bright fringes are separated by 3.27 mm. What is the wavelength?

A. 524 nm
B. 550 nm
C. 589 nm

26. Light of wavelength 536 nm from a distant source is incident on a single slit 0.750 mm wide, and the resulting diffraction pattern is observed on a screen 3.50 m away. What is the width of the central maximum?

A. 0.75 mm
B. 2.50 mm
C. 5.00 mm
D. 402 mm
E. 715 mm

27. A beam of white light (a mixture of many wavelengths and frequencies) incident on a glass prism is dispersed into its component colours, as shown below.




From these observations of the spectrum, one can conclude that:

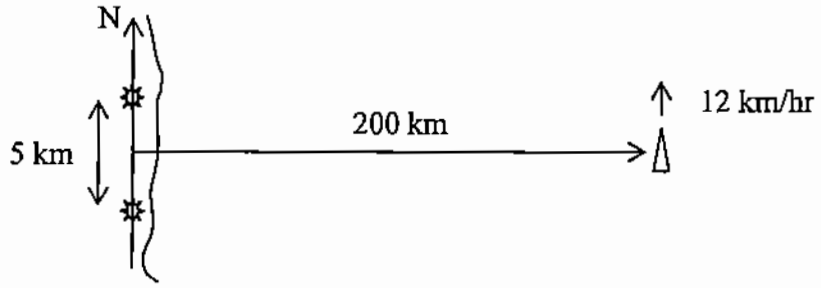
A. the index of refraction decreases as frequency decreases.
B. the index of refraction decreases as wavelength decreases.
C. the index of refraction, $n$, is a constant for a particular material and not a function of wavelength or frequency.

28. Light enters a medium with a refractive index $n_2 = 2.0$ from a medium with refractive index $n_1 = 1.5$. The ratio of the speed of light in medium 2 to the speed of light in medium 1 is:

A. 3/4
B. 1 (the speed of light is constant)
C. 4/3

***The next two questions refer to the following situation:***

Two radio antennas are 5 km apart on a north-south axis on a seacoast. The antennas broadcast identical AM radio signals, in phase, at a frequency of 1.2MHz. An ocean liner, 200 km offshore, travels due north at a speed of 12 km/hr and passes east of the antennas. A radio on board the ship is tuned to the broadcast frequency. At a certain time, the ship is an equal distance from each antenna. The speed of radio waves is the same as that of light, $3 \times 10^8$ m/s. Distances are such that small angle approximations apply.




29. The reception of the radio signal on the ship is a maximum when the ship is an equal distance from each antenna.

A. True
B. False

30. The time interval until the next occurrence of a maximum in radio reception is closest to:

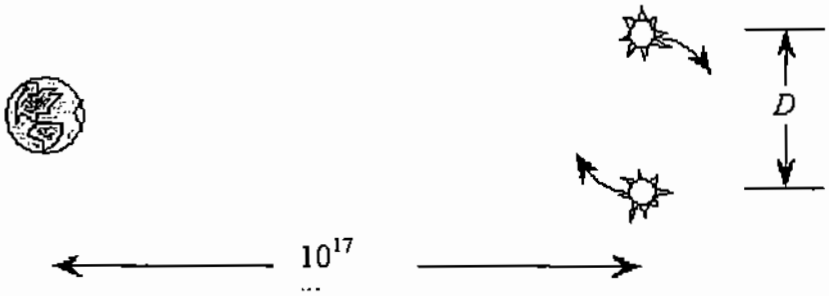
A. 10 min
B. 20 min
C. 30 min
D. 40 min
E. 50 min

31. A glass plate 2.50 cm thick, with an index of refraction of 1.40, is placed between a point source of light with wavelength 540 nm (in vacuum) and a screen 10.0 cm from the source. How many wavelengths are there in a direct line (shortest distance) between the source and the screen?

    A. $1.85 \times 10^5$.
    B. $2.03 \times 10^5$.
    C. $2.59 \times 10^5$.

***The next two questions refer to the following situation:***

A binary star system is $10^{17}$ meters (approximately 10 light years) from Earth. The two stars in the system move in circular orbits and remain a distance *D* apart. An earth-based telescope whose circular aperture is 10 m in diameter observes light (wavelength 540 nm) coming from the stars.




32. What is the minimum distance *D* between the stars that will allow the telescope to resolve the binary system as comprising two well-separated stars?

    A. $2.50 \times 10^7$ m
    B. $3.00 \times 10^8$ m
    C. $5.40 \times 10^9$ m
    D. $6.59 \times 10^9$ m
    E. $5.40 \times 10^{10}$ m

33. If better resolution were desired, which of the following would most directly improve the resolution?

    A. Making observations at a longer wavelength.
    B. Making observations at a shorter wavelength.
    C. Making observations using white light (a range of wavelengths) so that more of the incident light could be used.

34. A certain prism (n = 1.39) in air has a critical total internal reflection angle θ. If this prism is immersed in water (refractive index of water is $n_w$=1.33), how does the critical angle for total internal reflection change?

A. It remains the same.
B. It decreases.
C. It increases.

35. An object is a distance 30.0 cm to the left of the centre of a solid silver coated sphere which has a diameter of 30.0 cm. What is the magnification of the resulting image (the sphere acts like a curved mirror)?

A. M = + 1.00
B. M = + 1/3
C. M = - 1/3
D. M = -1.00
E. M = - 3

36. Two slits spaced 0.055 mm apart are placed 2.700 m from a screen and illuminated by coherent light of wavelength 660 nm. The intensity at the centre of the central maximum is $I_o$. What is the smallest distance on the screen from the centre of the central maximum to where the intensity is $I_o/2$? *(neglect the width of the slits).*

A. 2.0 mm
B. 4.0 mm
C. 8.0 mm

37. A single slit with a width of 50.0 μm is illuminated by parallel light rays with a wavelength of 632 nm. The far field diffraction pattern is observed on a screen that is a distance of 2.30 m from the slit. The intensity at the middle of the central maximum is $I_0$. What is the intensity at a point on the screen defined by an angle of 1.00° from the centre of the pattern?

A. 0.00609 $I_o$
B. 0.0123 $I_o$
C. 0.0460 $I_o$
D. 0.405 $I_o$
E. 0.500 $I_o$

***Did you enter your Name, Student ID and Section (J = ?) correctly on the answer sheet?***
***(Failure to do so could result in a mark of zero)***

***Check that you have filled in all your answers. Blanks receive zero.***