PHS 121 QUESTIONS

QUESTIONS FROM LMS

1. If the minimum wavelength recorded in the continuous x-ray spectrum from a 50kV tube is $0.247\,\mathring{A}$, calculate the value of Planck's constant.

2. Calculate the minimum wavelength of the radiation emitted by an X-ray tube operated at 30kV.
If λ_{min} is the minimum wavelength of the x-rays produced by the x-ray tube, then

$$eV = \frac{hc}{\lambda_{min}}$$

$$\lambda_{min} = \frac{hc}{eV}$$

$$\lambda_{min} = \frac{6.63\times10^{-34}\times3\times10^{8}}{1.6\times10^{-19}\times30\times10^{3}}$$

$$\lambda_{min} = 0.413\times10^{-10}$$

$$\lambda_{min} = 0.413\,\mathring{A}$$

3. If an object 30cm in front of a convex mirror that has a focal length of 60cm, how far behind the mirror will the image to an observer

4. What is the smallest Bragg angle for x-ray of wavelength 30pm to reflect from reflecting planes spaced 0.3nm apart in a calcite?
From Bragg's law

$$2d\sin(\theta) = n\lambda$$

At minimum angle, $n = 1$

$$d = spacing = 0.3\,nm = 0.3\times10^{-9}m = 3\times10^{-10}m$$

$$\lambda = 30\,pm = 30\times10^{-12}m = 3\times10^{-11}m$$

$$\theta = \arcsin\left(\frac{1\times3\times10^{-11}}{2\times3\times10^{-10}}\right)$$

$$\theta = 2.9$$

5. Determine the wavelength of the x-ray that was Bragg-diffracted by a cobalt crystal of interatomic spacing of $4.07\times10^{-10}m$, if the first order scattering angle is 24

6. If the thickness of oil, water and glass together in a set up are 4cm, 6cm and 5cm respectively and their refractive indices are 1.26, 1.33 and n_g respectively. Find the value of n_g if the apparent position of an object at the bottom is 12cm
Solution
Apparent depth = sum of thicknesses per refractive indices

$$AD = \frac{d_i}{n_1} + \frac{d_2}{n_2} + \frac{d_3}{n_3}$$
$$12 = \frac{4}{1.26} + \frac{6}{1.33} + \frac{5}{n_g}$$
$$12 = 3.175 + 4.511 + \frac{5}{n_g}$$
$$12 = 7.686 + \frac{5}{n_g}$$
$$\frac{5}{n_g} = 12 - 7.686$$
$$\frac{5}{n_g} = 4.314$$
$$n_g = \frac{5}{4.314}$$
$$n_g = 1.159$$
$$n_g = 1.6$$

7. Two lenses of focal length 9cm and -6cm are placed in contact. Calculate the focal length of the combination. Answer: -18cm

8. Violet light of wavelength 400nm ejects with a maximum kinetic energy of 0.860ev from sodium metal. What is the binding energy of electrons to sodium metal.

$$BE = E - KE$$
$$KE = 0.86\,eV$$
$$E = \frac{hc}{\lambda}$$
$$E = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{4.0 \times 10^{-7}}$$
$$E = 4.97 \times 10^{-19}\,J$$
$$1.6022 \times 10^{-19}\,J = 1\,eV$$
$$E = 3.1\,eV$$
$$BE = E - KE$$
$$BE = 3.1\,eV - 0.86\,eV$$
$$BE = 2.24\,eV$$

9. What is the wavelength of EM radiation that ejects 2.0eV electrons from calcium metal, given that binding energy is 2.71eV, what type of EM radiation is this? Answer: 263 or 264nm

$$E = BE + KE$$
$$E = \frac{hc}{\lambda}$$

10. The operation of the electron microscope depends on the principle of
a. Photoelectric effect
b. Particle nature of electrons
c. Wave nature of electrons
d. Dual nature of matter

11. The maximum kinetic energy emitted from the surface of a metal has a value equal to twice its work function. By what factor should the frequency of incident radiation be increase so that the kinetic energy is doubled

$E_1 = h(f_1 - f_o) = 2hf_o$
$f_1 - f_o = 2f_o$
$f_1 = 3f_o$
$E_2 = h(f_2 - f_o) = 2h(f_1 - f_o)$
$f_2 - f_o = 2f_1 - 2f_o$
$f_2 = 2f_1 - f_o$
$f_2 = 2(3f_o) - f_o$
$f_2 = 6f_o - f_o$
$f_2 = 5f_o$
$\frac{f_2}{f_1} = \frac{5f_o}{3f_o} = \frac{5}{3}$

12. A 3.0m long string sustains a three loop standing wave pattern as shown. The wave speed is $1 \times 10^2 m/s$. What is the frequency of the wave?

$3m = 1.5\lambda$
$\lambda = 2$
$v = f\lambda$
$f = \frac{v}{\lambda}$
$f = \frac{100}{2}$
$f = 50\,Hz$

13. The equation for displacement of two identical particles performing SHM is given by $x_1 = 4\sin\left(20t + \frac{\pi}{6}\right)$ and $x_2 = 10\sin\omega t$. Find what value of %omega where both particles have the same energy.

$E = \frac{1}{2} m\omega^2 A^2$ $A \rightarrow Amplitude$
$A_1 = 4$, $\omega_1 = 20$, $m_1 = m$
$A_2 = 10$, $\omega_2 = \omega$, $m_2 = m$
$E_1 = E_2$
$\frac{1}{2} m_1 \omega_1^2 A_1^2 = \frac{1}{2} m_2 \omega_2^2 A_2^2$
$\frac{1}{2} m 20^2 4^2 = \frac{1}{2} m\omega^2 10^2$
$\omega^2 = 64$
$\omega = 8$

14. In a young’s double slit experiment, the slits are separated by 0.28mm and the screen is placed 1.4m away. The distance between the central bright fringe and the fourth bright fringe is measured to be 1.2cm. Determine the wavelength of the light used.
d = 0.28mm = 0.28 times 10^{-3}m = 2.8 time 10^{-4}m
l = 1.4m

y =

15. The dispersive powers of a crown and flint glasses are 0.02 and 0.04 respectively. In an achromatic combination of lens is 40cm. The focal length of crown will be:

$$\frac{p_1}{f_1}+\frac{p_2}{40}=0$$
$$\frac{0.02}{f_1}+\frac{0.04}{40}=0$$
$$f_1=-20\,cm$$

16. A lens of crown glass of dispersive power 0.064 has focal length of 45cm. Calculate the focal length of a flint glass of dispersive power of 0.044 which form an achromatic combination with the first

$$\frac{p_1}{f_1}+\frac{p_2}{f_2}=0$$
$$\frac{0.064}{45}+\frac{0.044}{f_2}=0$$
$$\frac{0.064}{45}=\frac{-0.044}{f_2}$$
$$f_2=\frac{-0.044\times 45}{0.064}$$
$$f_2=-30.9375$$
$$f_2=-31$$

17. A microwave signal is transmitted by a radar station. The signal is reflected from an aeroplane. The aeroplane is at a height of 30km directly above the radar station. The time between the signal transmitted and the reflected signal being received back at the radar is
v = 2x over t
t = 2x over v

$$t=\frac{2\times 30\times 10^3}{3\times 10^8}$$
$$t=2\times 10^{-4}s$$

18. The equation of a sinusoidal transverse traveling along a string is $\phi(x,t)=A\sin(5dx-40dt)$ where $A=\left(\frac{10}{d}\right)m$, x and ϕ are measured in meters and t is in seconds. What is the
a. Wavelength of the wave
b. Frequency of the wave

A wave is given as
$$y=A\sin(kx-\omega t)$$
$$\omega=40\,d=2\pi f$$
$$f=\frac{20}{\pi}d$$

$$k=\frac{2\pi}{\lambda}$$
$$5d=\frac{2\pi}{\lambda}$$
$$\lambda=\frac{2\pi}{5d}$$

19. In young's double-slit experiment, a set of parallel slits with a separation of 0.102mm is illuminated by light having wavelength of 575nm and the interference pattern observed on a screen 3.5m from the slits. What is the difference in path lengths from the two slits to the location of the dark fringe on the screen away from the center of the pattern?
d = 0.102mm = 0.102 times 10^{-3}m = 1.02 times 10^{-4}

$$\lambda=575nm=575\times10^{-9}m=5.75\times10^{-7}m$$
$$l=3.5m$$
$$y=?$$

Where $n=0.5$

$$dy=n\lambda l$$
$$y=\frac{n\lambda l}{d}$$
$$y=\frac{0..5\times5.75\times10^{-7}\times3.5}{1.02\times10^{-4}}$$
$$y=9.865\times10^{-3}$$

NB: I didn't see the answer in the options please correct me

20.An object is placed at the bottom of a glass block 18cm thick, if it is displaced 6.1cm upwards, find the refractive index of the glass.

$$n=\frac{RD}{RD-d}$$
$$n=\frac{18}{18-6.1}$$
$$n=1.51$$

21. If a plane mirror is rotated through angle 50, then the reflected ray will be rotated through: Answer: 100

22. Find the focal length of a corrective eye glass lenses that would allow a farsighted person with a near point distance of 176cm to read a book at a distance of 10.1cm
v = -176cm
u = 10.1
f = uv over {u+v}
f = 10.71cm

22. The radius of the first Bohr is a_o. The nth orbit has a radius?

23. The displacement of a particle performing simple harmonic motion is given by $x=8\sin(\omega t)+6\cos(\omega t)$, where x is in cm and t is in seconds. The amplitude of the motion is

24. Find the De Brogile wavelength of an electron moving with the velocity 1000m/s

25. An object at the bottom of a pool 20cm deep was observed to be at 14cm position. Find the angles of incidence of the object if the angle of refraction of an observer vertically above is 36.

26. The threshold wavelength of photoelectric emission of a metal is $4000\,\mathring{A}$. Then the minimum energy required to eject photo electron is
a. 4.96eV
b. 3.1eV
c. 49.6eV
d. 31eV

27. A microscope was focused on a scratch at the bottom of a jar when a liquid was poured to the depth of 8cm. The microscope was moved vertically upward through a distance of 1.4cm to bring the scratch into focus. Find the refractive index of the liquid
a. 1.0
b. 1.4
c. 1.3
d. 1.2

28. If the wavelength of an electromagnetic radiation is doubled, what will happen to the energy of photons?

29. An ambulance traveling at half the speed of sound (v=172m/s) emits a sound of frequency 5kHz. At what frequency does a stationary listener hear the sound as the plane approaches?
a. 5kHz
b. 15kHz
c. 10kHz
d. 20kHz

30. When a block of mass m is suspended from the free end of a massless spring having force constant k, its length increases by y. When the block is slightly pulled downwards and released, it starts executing SHM with amplitude A and angular frequency {%omega}. The total energy of the system comprising the block and spring is
a. $\frac{1}{2}m\omega^2A^2$
b. $\frac{1}{2}m\omega^2A^2+\frac{1}{2}ky^2$
c. $\frac{1}{2}ky^2$
d. $\frac{1}{2}m\omega^2A^2-\frac{1}{2}ky^2$

31. Cs-137 has a half-life of 30 years. Approximately how much time is required for the radiation of this isotope to decrease 1% of its original level?
a. 100yrs

b. 150yrs
c. 200yrs
d. 250yrs

32. Calculate the disintegration energy when $^{232}_{92}U$ (mass=232.07315U) decays to $^{228}_{90}Th$ (mass=228.028741U0). (Where mass of proton = 1.007276U), mass of neutron = 1.008665U, mass of alpha particle = 4.002603U, 1U = 931.5MeV)
a. 2.4MeV
b. 6.3MeV
c. 5.4MeV
d. 8.3MeV

33. An object has a speed of 100m/s accurate to 0.01%. What fundamental accuracy can we locate its position if the object is a bullet of mass 0.05kg

34. Which of the relation between acceleration and displacement of four particles given below in simple harmonic?
a. $a_x = +2x$
b. $a_x = +2x^2$
c. $a_x = -2x^2$
d. $a_x = -2x$

35. For a particle executing simple harmonic motion, which of the following statements is not correct?
a. Total energy is always directed towards a fixed point
b. Restoring force is always directed towards a fixed point
c. Restoring force is maximum at the extreme positions
d. Acceleration of the particle is maximum at the equilibrium position

36. Given the refractive index of ait to glass to be 2/3, of air to water to be 4 over 3, what is the refractive index of water to glass?
a. 9/8
b. 3/4
c. 8/9
d. 4/3

37. A mass on a spring has an angular frequency of 2.5rad/s. The spring constant is 27.21N/m and the system's kinetic energy is 2.92J when t=1.56s. What is the amplitude of oscillation? Assume phase $\phi = 0$ and that the system reaches its maximum displacement at t=0
a. 61.6cm
b. 52.7cm
c. 40.0cm
d. 90.1cm

38. Determine the approximate frequency of a photon whose energy is 1.875eV (Speed of light = 3.0 times 10^{8} m/s, 1U = 931.5MeV, Planck's constant, $mass\,of\,electron = 9.11\times10^{-31}\,kg$, $eV = 1.6\times10^{-19}\,C$, $Rydberg\,constant = 1.1\times10^{7}\,m$)
a. $2\times10^{14}\,Hz$
b. $3\times10^{14}\,Hz$

c. $4.\times10^{14}\,Hz$

d. $5\times10^{14}\,Hz$

39. A 25kg child bouncing on a trampoline can be roughly modeled as a damped harmonic oscillator. If the height that the child bounces to (the oscillation amplitude) drops to one-third of its original value in 1.5s, what is the value of the damping constant?

a. 34kg/s
b. 37kg/s
c. 31kg/s
d. 40kg/s

40. The length of a pendulum changes by thermal expansion. If the length increases by 0.1% what would be the change in period

a. Decrease by 0.1%
b. Decrease by 0.99
c. Increase by $\sqrt{1.001}$
d. Increase by 0.1%

41. Given the wave, y(x, t) = 0.5cm sin {2t} cos {(0.4{%pi}x)}, calculate the distance between two consecutive nodes.

a. 3m
b. 2.5m
c. 2m
d. 1.5m

42. A small marble slides along the inside surface of a cup which has a cross-sectional shape given by y=0.100x^2, where x is the displacement from the center of the cup and y is the height of the surface above the bottom. If a harmonic oscillation is started, what would be its frequency?

a. 1.96rad/s
b. 1.40rad/s
c. 1.97rad/s
d. 0.223rad/s

42. A laser with a power output of 2.00mW at a wavelength of 400nm is projected onto calcium metal

a. How many electrons per second are ejected?
d. What power is carried away by the electrons, given the binding energy is 2.71eV

a. 4.02 times 10^{15}s; 0.256Mw
b. 4.02 times 10^{15}s; 0.356Mw
c. 4.02 times 10^{14}s; 0.256Mw
d. 4.02 times 10^{14}s; 0.356Mw

43. A wave given as $y(x,t)=(0.4\,cm)\sin\left[\frac{t}{0.2}-0.3\,x\right]$. Find the amplitude of the particle velocity.

a. 4m/s
b. 6m/s
c. 5m/s
d. 2m/s

44. What is the maximum velocity of electrons ejected from a material by 80nm photons, if they are bound to the material by 4.73eV??
a. 1.95 times 10^6 m/s
a. 1.95 times 10^7 m/s
a. 2.95 times 10^6 m/s
a. 2.95 times 10^7 m/s

45. Concerning a wave on a string, provided the other variable is kept constant, which of the following will give a straight line graph?
a. v versus T
b. v versus m
c. c versus $\frac{1}{\sqrt{m}}$
d. v versus $\sqrt{T}$

46. Calculate the wavelength in nm of electrons which have been accelerated from rest through a potential difference of 54V
a. 0.27A
b. 0.34A
c. 1.67A
d. 13.2A

GENERAL OPTICS

1. What type of wave is a light wave in terms of whether a material medium is required?
2. What type of wave is a light wave in terms of the direction of the wave?
3. What are the two types of sources of light?
4. What are luminous and non-luminous objects?
5. Objects that allow light to pass through them are called _____.
6. Objects that don't allow light to pass through are called _____.
7. In what pattern does light travel?
8. What is another name for the ray model of light?
9. What is a ray of light or a `light ray`?
10. A train of waves can be represented with what?
11. A group of light rays is called?
12. What are types of these groups of light rays?
13. What is a wavefront?
14. What is Huygen's principle used for?
15. State Huygen's principle
16. When wave fronts are spherical, the rays radiate from what point of the sphere?

GENERAL REFLECTION
1. What is reflection
2. What is angle of incidence
3. What is the angle of reflection
4. State the laws of reflection
5. What are the types of reflection based on the surfaces on which they land?

6. For each point on the object there is a corresponding image point: True/False

IMAGES
1. What are the types of images
2. Give the characteristics of each type of image.

PLANE MIRRORS
1. Name 5 characteristics of images formed on plane mirrors
2. What type of image is formed on a plane mirror?
3. When two plane mirrors are inclined at an angle θ, what is the formula for the number of images formed n
4. Give 5 uses of plane mirrors
5. What is the glancing angle?
6. What is deviation?

CURVED MIRRORS
1. What is another name for concave mirrors?
2. What is another name for convex mirrors?
3. What are the characteristics of images formed by a convex mirror?
4. Draw the following cases for concave mirrors and give the characteristics of the images formed:
i. An object placed behind the center of curvature
ii. An object placed at the center of curvature
iii. An object placed between c and f
iv. An object placed at f
v. An object placed between f and the pole