ALL THE FORMULAS YOU NEED IN PHY 103

$$N = N_0 e^{-\lambda t}$$

PAST EXAMINATION AND TEST QUESTIONS WITH THEIR SOLUTIONS

BASIC DEFINITIONS AND HINTS ATTACHED TO THE SOLUTIONS

SELF EXPLANATORY

PHY103 AT YOUR FINGER TIP

COMPILED BY

DR-SMOKE

FORMULAS YOU NEED

S/N	LAW	FORMULA
1.	Velocity	V=Fλ or V= λ/T F=frequency and λ=wavelength(m)
2.	Frequency	F = 1/T T = Period (in secs)
3.	Period	1/F F = frequency in Hertz (Hz)
4.	Wave Equation	= Asin$\left(\frac{2\pi x}{\lambda} - wt\right)$ Where Y = Vertical displacement of the vibrating particle λ = Wavelength of wave A= Amplitude x= Horizontal coordinate of the vibrating particle from origin w= $2\pi f$ = angular speed t = time of displacement
5.	Angular Speed (w)	$2\pi f$ Where f = frequency
6.	Refractive index (n) part 1	n=$\frac{Sin\ i}{Sin\ r}$ Where i= angle of incidence and r= angle of refraction
6b	Refractive index (n) part 2	n=$\frac{Real\ depth}{Apparent\ depth}$

6c	Refractive index (n) part 3	$n = \frac{1}{Sin\ C}$ Where C = Critical angle
6d	Refractive index (n) part 4	n = $\frac{Sin\frac{1}{2}(A+D)}{Sin\frac{1}{2}A}$ A is the angle of prism, and D is the angle of minimum deviation
7	Number of images formed from two mirrors placed at an angle to each other	n= $\frac{360}{\theta}$ - 1 θ= angle of inclination
8.	Focal length f	f = r/2 Where r = radius of curvature
9.	Mirror formula	1/f = 1/v + 1/u V = Image distance and u = Object distance Note: v is negative for convex mirror 1/f = -1/v + 1/u
10.	Magnification	M=v/u=hi/ho hi = image height/length, ho= object height/length
11.	Lens formula	1/f = 1/v + 1/u Note: for diverging lens "f" is negative

12	Velocity of sound	V=2d/t Where d=distance and t=time
13.	Fundamental frequency for closed pipes	F_0= v/4l harmonics = F_0, $3f_0$, $5F_0$…. Overtones = $3F_0$, $5F_0$, $7F_0$… Therefore First overtone = Second harmonics
14.	Fundamental frequency for open pipes	F_0=v/2l Overtones = $2F_0$, $3F_0$, $4F_0$…
15.	Doppler's effect To calculate the apparent frequency when an observer is moving towards a source	$f = \frac{(V + V_0)f_0}{V}$ V_0=Speed of the observer V = speed of sound (340m/s) F_0=frequency of the source F = apparent frequency
16.	Doppler's effect To calculate the apparent frequency when the source is moving towards the observer	$f = \frac{V}{(V + V_0)f_0}$ V_0=Speed of the observer V = speed of sound (340m/s) F_0=frequency of the source F = apparent frequency
17.	Half-life ($t_{1/2}$)	$t_{1/2}$= 0.693/λ
18.	Calculating the number of atoms remaining after a particular time t during radioactive decay.	$N= N_0e^{-\lambda t}$ Where N_0 is the initial number of atom at time t=0 and N is the number of atom at

		time t=t, λ = decay constant.
19.	Einstein's photoelectric equation	**E = W + K.E** **E = hf** (h = planks constant=6.6×10^{-34}Js and f = frequency of the photon) **W = work function =** hf_0 (f_0 is the threshold frequency of the photon) K.E= Kinetic Energy which is given by **½mv²** (Where v is the velocity of the photoelectron and m is the mass)
20.	Energy content of a photon (E)	**E = hf** **But f = c/λ** Where c = speed of light (3×10^{8}m/s) λ = wavelength of the photon in meter

TEST QUESTIONS AND EXAM QUESTIONS COMBINED

UNIVERSITY OF ABUJA

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

2016/2017 SECOND SEMESTER EXAMINATION OCTOBER 2017

COURSE CODE: PHY 103

COURSE TITLE: WAVES, OPTICS, SOUNDS AND MODERN PHYSICS

INSTRUCTION: ATTEMPT ALL QUESTION IN SECTION A AND THREE QUESTIONS IN SECTION B

TIME ALLOWED: 3HRS

ALL SYMBOLS HAVE THEIR USUAL MEANINGS

SECTION A

(a) State the mathematical representation of wave, explain all the terms used

(b) When is interference of wave said to be constructive

(c) A candle is placed 41cm in front of a concave spherical mirror of radius 60cm. where is the image?

(d) How does wind affects the velocity of sound?

(e) What are upper partials? Hence, establish the point when a note can be called an octave

(f) How different is ultrasonic wave from infrasonic wave?

(g) Use the resonance curve to explain the Q-factor

(h) The lowest note emitted by a stretched string has a frequency of 20Htz, how many overtones are there between 20Htz and 160Htz?

(i) State and explain the Einstein photoelectric equation

(j) When does polarization occurs? State the uses of polaroids

SECTION B

1. (a) What do you understand by Doppler effect?

   (b) Deduce the characteristics of the waves represented by the equations:

$Y_1 = 4\sin(8t + 5x)$ and $Y_2 = 4\sin(8t - 5x)$. What is the equation of the resulting wave when the two waves are superposed. Identify the type of wave, if y is in mm, x is in m and t is in seconds, determine the various terms in the wave.

(c) Determine the apparent frequency when an observer is moving towards a stationary sound source.

2. (a) Briefly discuss the resonance tube method and the end correction (c)

   (b) Suppose a car A approaches R with a velocity of 20m/sec when sounding a note of 1000Htz from its horn, and that another car B behind A is travelling towards A with a velocity of 30m/s estimate the apparent frequencies.

   (c) Legitimize this equation: $N = N_0e^{-\lambda t}$
3. (a) Explain X-ray spectra using graphical method

   (b) an object of length 5cm lies along the principal axis and in front of a concave mirror which is 15cm away from the closer edge of the object. If the focal length of the mirror is 25cm, what would be the length of the image?

   (c) How can you minimize echo in a room?
4. (a) when does music becomes noise?

   (b) A radioactive substance has a half-life of 40days, if the initial number of atoms in the sample is 3×10^{20}, how many atoms would remain at the end of 320 days?

   (c) State the characteristics of images formed by a plane mirror.

SOLUTIONS TO EXAM QUESTIONS

SECTION A

a. Y = Asin$\left(\frac{2\pi x}{\lambda} - wt\right)$

Where Y = Vertical displacement of the vibrating particle

λ = Wavelength of wave

A= Amplitude

x= Horizontal coordinate of the vibrating particle from origin

w= $2\pi f$ = angular speed

f= frequency of the wave = $\frac{v}{\lambda}$

v= velocity of the wave

t= time of displacement

b. The interference of waves is said to be constructive when the superposition of the two identical waves result to increased disturbance (i.e they reinforce each other).

c. Using the mirror formula 1//f = 1/v + 1/u (note: f=r/2)

Where focal length f= 60/2 = 30cm, Object distance u=41cm, image distance v=?

1/f = 1/v + 1/u will be 1/30 = 1/v + 1/41

1/v = 1/30-1/41 will be 1/v = 0.033 - 0.024

1/v = 0.009 (Making v the subject formula by cross multiplying)

V = 1/0.009 = 111cm

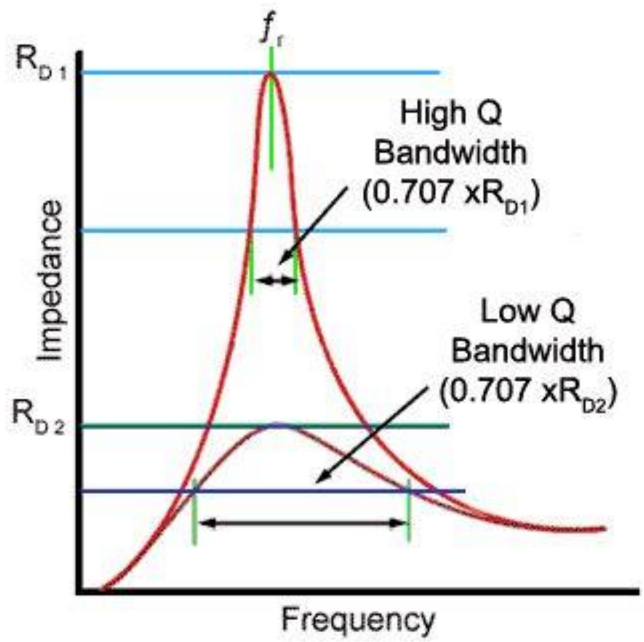
Since V is positive, the image is real, and because it is greater than the focal length, the image will be located **beyond the center of the curvature.**

d. The speed of sound increases or decreases according to direction of wind. If wind is blowing in the direction of propagation of sound, the speed of the sound increases, while if it is blowing in a direction opposite to that of sound, the speed decreases.

e. Upper partials are also known overtones or harmonics, and they are higher frequencies which are integral or whole number multiples of the fundamental frequency and can also be produced in the string. 8 notes make up an octave, i.e the 8th note is the beginning of a new octave, so it is at that point you call a note an octave see example below:If you played C D E F G A B C on a piano, you've reached the next octave because the second C is the eighth note played from the first.

f. Ultrasonic sounds have a frequency above the upper limit of human hearing (20,000Hz), While infrasonic sounds have a frequency below the lower limit of human hearing (20hz).

g.



The Q, or quality factor of a resonant circuit is a measure of the goodness or quality of a resonance circuit. Q is also the ratio of power stored to power dissipated in the circuit reactance and resistance respectively.

h. Overtone is the next highest frequency after the fundamental frequency i.e if the fundamental frequency is f_0, then the first overtone is $2f_0$ and so on. For this question, the fundamental frequency f_0 = 20Hz.
The number of overtones depends on the number of fundamental frequencies between 20Htz and 160 Hz; therefore, 160 – 20 = 140Hz
To get the number of overtones, we will divide the number of frequency by the fundamental frequency.
Overtone = 140/20 = 7 overtones

i. When light falls on a metal surface, electrons are emitted. This is known as photoelectric effect. Einstein equation is given by **E = W + K.E**
E= hf total energy content of a single photon, h = plancks constant
W =hf$_0$ Work function which is given by hf$_0$ and f$_0$ = threshold frequency of the photon
K.E = ½ mv^2 Kinetic energy where "V" is the velocity of the photoelectron of mass "m".

j. Polarization occurs when light waves travel in one plane.
Uses of polaroids
- Used in laboratory to produce and analyze plane polarized light
- Widely used as polarizing sun glasses
- They are used to produce three dimensional moving pictures
- They are used to improve color contrast in old oil paintings
- They are used to eliminate the head light glare in motor cars

SECTION B

1.

a. The apparent change in the pitch or frequency of sound due to relative motion of between the source of sound and the observer is known as **DOPPLER'S EFFECT**

b. Characteristics of the Y_1 and Y_2
- They both have the same Amplitude
- They both have the same maximum velocity as they pass through the mean position
- They both execute vibration about their mean position
- They are both moving in opposite direction i.e Y_1 is moving in the negative x-direction and Y_2 is moving in the positive x-direction

The resulting equation will be a standing equation, where Y = vertical displacement of the vibrating particles, x = horizontal coordinates of the vibrating particles from the origin, and t = time of displacement of the particles. This type of wave is known as **progressive wave.**

c. Suppose an observer is moving towards a stationary source of sound, and the speed of the observer is V_0 and the frequency of the source is f_0 and a wavelength of λ, we know that λ = V/f, the waves approaching the observer have a speed relative to that of the observer ($V + V_0$) where V is the speed of sound (340m/s).
Therefore, Apparent frequency = Relative velocity of sound/Wavelength
Mathematically $f = (V + V_0)/\lambda$ (Substituting the value of λ)
Then $f = (V + V_0)/V/f_0$ which will finally be $f = \frac{(V + V_0)f_0}{V}$

$$\mathbf{f = \frac{(V + V_0)f_0}{V}}$$

2. (a) Resonance tube method has to do with a resonance column apparatus. Vibration of air column can be set up in a resonance column apparatus. It consists of a long metal tube held vertically in a tall jar containing the water. The tube can be fixed in vertical position; the length of the air column can be varied by raising or lowering the tube. When the frequency of the wave in the column is equal to the natural frequency of the turning fork, a large sound is produced in the air column.
End correction: The antinode at the top of a tube does not exactly coincide with the top of the tube, but projects slightly above it by an amount "c" known as **end correction.**
(b) From the formula we derived in **1c,** we can solve for the apparent frequencies of A and B
V = 340m/s (It's a constant for speed of sound) V_0(for A)=20m/s and f_0=1000Hz
Apparent frequency for (A) $f = \frac{(V + V_0)f_0}{V} = \frac{(340 + 20)1000}{340} = \frac{(360)1000}{340} = \frac{360000}{340}$
= **1058.8Htz**
Apparent frequency for (B) $f = \frac{(V + V_0)f_0}{V} = \frac{(340 + 30)1000}{340} = \frac{(370)1000}{340} = \frac{370000}{340}$
= **1088.2Htz**
(c) The rate of decay of a radioactive element is found to be proportional to the number of atoms of the material present. Suppose there are N atoms of a radioactive element present at a time t, then the probable number of

disintegration per unit time or activity can be expressed by – dN/dt (The minus sign arises from the fact that N is decreasing with time). Since the rate of disintegration is proportional to the number of atoms present at a given time, we have

$$-\frac{dN}{dt} \propto N \text{ --------------------Eqn1}$$

When removing the proportionality sign, we will have

$$-\frac{dN}{dt} = \lambda N \text{------------------Eqn2}$$

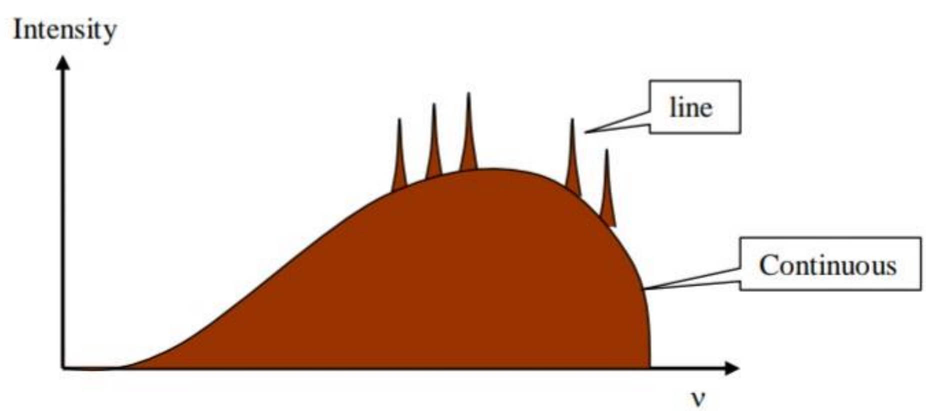
Where λ is the constant of proportionality called decay constant

By Integrating Eqn2, we will have

$$N = N_0 e^{-\lambda t} \text{---------------------Eqn3}$$

Where N_0 is the initial number of atom at time t=0 and N is the number of atom at time t=t

3. a. X-ray emission spectra: A piece of metal wire called anticathode is bombarded with highly accelerated electrons, this radiation can be analyzed with a crystal spectrometer. The observed emission is shown in the diagram below:



The emission spectrum consists of two parts, (a) Continuous (b) Line

(b) Image length (h_i)=? Object length (h_o)= 5cm, Object distance (u)=15cm, image distance (v) =? Focal length (f)=25cm

Using the mirror formula to get image distance.

1/f = 1/v + 1/u which will be 1/25 = 1/v + 1/15

1/v = 1/25 – 1/15 will be 1/v = -2/75 (Lets cross multiply)

1 x 75 = -2 x v we will have 75 = -2v, dividing both sides by -2

$V = 75/-2 = -37.5$cm

From the formula for Magnification $M = v/u = h_i/h_o$

But we have v = 37.5cm, u = 15cm, h_o= 5, but h_i=?

We will be using $v/u = h_i/h_o$

$37.5/15 = h_i/5$ (Lets cross multiply)

$37.5 \times 5 = h_i \times 15$ which will be $187.5 = 15h_i$ (dividing both sides by 15)

We will have **h_i = 12.5cm**

(c) Because sound waves bounce off hard surfaces, the best way to minimize interior echoes is to include soft furnishings where possible.

4. (a)Music becomes noise when it is no longer pleasant to the ear.

   (b) half-life $t_{1/2}$= 40 days, N_0= 3×10^{20}, t = 320days, N = ?

   Using this formula $N= N_0e^{-\lambda t}$ but decay constant λ = 0.693/half-life

   Therefore, λ = 0.693/40= 0.017.

   $N= N_0e^{-\lambda t}$ will be $N= 3 \times 10^{20}e^{-0.017 \times 320}$

   $N = 3 \times 10^{20} \times e^{-5.44}$ which will be $N = 3 \times 10^{20} \times 0.0043$

   Therefore, **$N = 129 \times 10^{16}$**

   - The image formed is virtual
   - The distance of the image behind the mirror is the same as the distance of the object in front of the mirror
   - The size of the image is same as the size of the object
   - The image formed is laterally inverted.