Answers and Solutions

Wave Nature and Interference of Light

1. (a) Corpuscular theory explains refraction of light.
2. (c) According to Corpuscular theory different colour of light are due to different size of Corpuscules.
3. (b)
4. (c) According to Plank's hypothesis, black bodies emits radiations in the form of photons.
5. (d) The coherent source cannot be obtained from two different light sources.
6. (c) Huygen's wave theory fails to explain the particle nature of light (*i.e.* photoelectric effect)
7. (d) Interference is shown by transverse as well as mechanical waves.
8. (c) $I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2 = (\sqrt{I} + \sqrt{4I})^2 = 9I$

   $I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2 = (\sqrt{I} - \sqrt{4I})^2 = I$
9. (c)
10. (b) The idea of secondary wavelets is given by Huygen.
11. (c) Monochromatic wave means of single wavelength not the single colour.
12. (d) Sound wave and light waves both shows interference.
13. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\sqrt{\frac{I_1}{I_2}} - 1}\right)^2 = \left(\frac{\sqrt{\frac{9}{1}} + 1}{\sqrt{\frac{9}{1}} - 1}\right) = \frac{4}{1}$
14. (a) A wave can transmit energy from one place to another.
15. (d) $\frac{I_1}{I_2} = \frac{1}{25}$; $\therefore \frac{a_1^2}{a_2^2} = \frac{1}{25} \Rightarrow \frac{a_1}{a_2} = \frac{1}{5}$
16. (a) For interference phase difference must be constant.
17. (c) Interference is explained by wave nature of light.
18. (b) Coherent time $= \frac{\text{Coherencelength}}{\text{Velocity of light}} = \frac{L}{c}$
19. (c) $\frac{a_1}{a_2} = \frac{3}{5}$

   $\therefore \frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(3+5)^2}{(3-5)^2} = \frac{16}{1}$
20. (b) Colour's of thin film are due to interference of light.
21. (c) For constructive interference path difference is even multiple of $\frac{\lambda}{2}$.
22. (c) Two coherent source must have a constant phase difference otherwise they can not produce interference.
23. (a) Phenomenon of interference of light takes place.
24. (c) Transverse waves can be polarised.
25. (a) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\sqrt{\frac{I_1}{I_2}} - 1}\right)^2 = \left(\frac{\sqrt{\frac{4}{1}} + 1}{\sqrt{\frac{4}{1}} - 1}\right)^2 = \frac{9}{1}$
26. (a) Reflection phenomenon is shown by both particle and wave nature of light.
27. (b) When two sources are obtained from a single source, the wavefront is divided into two parts. These two wavefronts acts as if they emanated from two sources having a fixed phase relationship.
28. (b) $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{100} = 3 \times 10^6 m$
29. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\sqrt{\frac{I_1}{I_2}} - 1}\right)^2 = \left(\frac{\sqrt{\frac{25}{4}} + 1}{\sqrt{\frac{25}{4}} - 1}\right)^2 = \frac{49}{9}$
30. (a) Wavefront is the locus of all the particles which vibrates in the same phase.
31. (b) Direction of wave is perpendicular to the wavefront.
32. (d) Origin of spectra is not explained by Huygen's theory.
33. (d) The refractive index of air is slightly more than 1. When chamber is evacuated, refractive index decreases and hence the

wavelength increases and fringe width also increases.

34. (a) $I \propto a^2 \Rightarrow \frac{a_1}{a_2} = \left(\frac{4}{1}\right)^{1/2} = \frac{2}{1}$

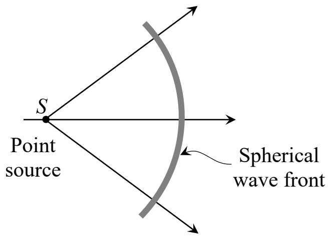
35. (a) The essential condition for sustained interference is constancy of phase difference.

36. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 = \left(\frac{\frac{4}{3}+1}{\frac{4}{3}-1}\right)^2 = \frac{49}{1}$

37. (b) Energy is conserved in the interference of light.

38. (c) $I \propto a^2$

39. (b)



40. (c) $I \propto a^2 \Rightarrow \frac{I_1}{I_2} = \left(\frac{a_1}{a_2}\right)^2 = \left(\frac{3}{4}\right)^2 = \frac{9}{16}$

41. (d) $\frac{I_1}{I_2} = \frac{100}{1}$

Now $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 = \left(\frac{\sqrt{100}+1}{\sqrt{100}-1}\right)^2 = \frac{121}{81} \approx \frac{3}{2}$

42. (b) $\phi = \pi/3, a_1 = 4, a_2 = 3$

So, $A = \sqrt{a_1^2 + a_2^2 + 2a_1.a_2 \cos\phi} \Rightarrow A \approx 6$

43. (b) $y_1 = a\sin\omega t$, and $y_2 = b\cos\omega t = b\sin\left(\omega t + \frac{\pi}{2}\right)$

So phase difference $\phi = \pi/2$

44. (c) For 2π phase difference → Path difference is λ

∴ For ϕ phase difference → Path difference is $\frac{\lambda}{2\pi} \times \phi$

45. (d) Resultant intensity $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

For maximum I_R, $\phi = 0^o$

$\Rightarrow I_R = I_1 + I_2 + 2\sqrt{I_1 I_2} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

46. (c) Newton first law of motion states that every particle travels in a straight line with a constant velocity unless disturbed by an external force. So the corpuscles travels in straight lines.

47. (d) Diffraction shows the wave nature of light and photoelectric effect shows particle nature of light.

48. (b) At point A, resultant intensity

$I_A = I_1 + I_2 = 5I$; and at point B

$I_B = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\pi = 5I + 4I$

$I_B = 9I$ so $I_B - I_A = 4I$.

49. (c)

50. (a) Photoelectric effect varifies particle nature of light. Reflection and refraction varifies both particle nature and wave nature of light.

51. (d) $y_1 = a\sin\omega t, y_2 = a\cos\omega t = a\sin\left(\omega t + \frac{\pi}{2}\right)$

52. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 = \frac{25}{1}$

53. (d) Laser beams are perfectly parallel. So that they are very narrow and can travel a long distance without spreading. This is the feature of laser while they are monochromatic and coherent these are characteristics only.

54. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 \Rightarrow \frac{I_1}{I_2} = \frac{9}{4}$

55. (b) $\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{3000 \times 10^{-10}} = 10^{15}$ *cycles/sec*

56. (a) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 = \left(\frac{\frac{1}{9}+1}{\frac{1}{9}-1}\right)^2 = \left(\frac{5}{4}\right)^2 = \frac{25}{16}$.

57. (c)

58. (d) For destructive interference path difference is odd multiple of $\frac{\lambda}{2}$.

59. (d) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 \Rightarrow \frac{a_1+a_2}{a_1-a_2} = 6$

$\frac{a_2}{a_1} = 7:5$

60. (b) $I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$

So, $I_{max} = I + 4I + 2\sqrt{I.4I} = 9I$

61. (b) In interference energy is redistribution.

62. (a) For interference frequency must be same and phase difference must be constant.

63. (c) When a beam of light is used to determine the position of an object, the maximum accuracy is achieved if the light is of shorter wavelength, because

$\text{Accuracy} \propto \frac{1}{\text{Wavelength}}$

64. (d) Intensity $\propto \frac{1}{(\text{Distance})^2}$

65. (d) Huygen's theory explains propagation of wavefront.

66. (c) Wave theory of light is given by Huygen.

67. (a) When light reflect from denser surface phase change of π occurs.

68. (a) Photoelectric effect explain the quantum nature of light while interference, diffraction and polarization explain the wave nature of light.

69. (a) Light is electromagnetic in nature it does not require any material medium for its propagation.

70. (c) For viewing interference in oil films or soap bubble, thickness of film is of the order of wavelength of light.

71. (b)

72. (d) For maximum intensity $\phi = 0°$

$\therefore\ I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi = I + I + 2\sqrt{II}\cos 0° = 4I$

Young's Double Slit Experiment

1. (a)

2. (c) In interference of light the energy is transferred from the region of destructive interference to the region of constructive interference. The average energy being always equal to the sum of the energies of the interfering waves. Thus the phenomenon of interference is in complete agreement with the law of conservation of energy.

3. (c) $\beta = \frac{\lambda D}{d} = \frac{5\times 10^{-7}\times 2}{10^{-3}} m = 10^{-3} m = 1.0\ mm$.

4. (c) Slit width ratio = 1 : 9

Since slit width ratio is the ratio of intensity and intensity $\propto$ (amplitude)^2

$\therefore I_1 : I_2 = 1:9$

$\Rightarrow a_1^2 : a_2^2 = 1:9 \Rightarrow a_1 : a_2 = 1:3$

$I_{max} = (a_1+a_2)^2,\ I_{min} = (a_1-a_2)^2 \Rightarrow \frac{I_{min}}{I_{max}} = \frac{1}{4}$

5. (a) $\beta \propto \frac{1}{d} \Rightarrow$ If d becomes thrice, then β become becomes $\frac{1}{3}$ times.

6. (c) $\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$ or $\frac{1.0}{\beta_2} = \frac{5000}{6000}$ or $\beta_2 = \frac{6000}{5000} = 1.2\ mm$.

7. (a) $\beta = \frac{6000\times 10^{-10}\times 25\times 10^{-2}}{10^{-3}}$

$= 150000\times 10^{-9} = 0.15\times 10^{-3} m = 0.015\ cm$.

8. (c) For brightness, path difference $= n\lambda = 2\lambda$

So second is bright.

9. (a) If one of slit is closed then interference fringes are not formed on the screen but a fringe pattern is observed due to diffraction from slit.

10. (d)

11. (d) $\beta = \frac{\lambda D}{d} \Rightarrow$ If D becomes twice and d becomes half so β becomes four times.

12. (c) Suppose slit width's are equal, so they produces waves of equal intensity say I'. Resultant intensity at any point $I_R = 4I'\cos^2\phi$ where ϕ is the phase difference between the waves at the point of observation.

For maximum intensity $\phi = 0^o \Rightarrow I_{max} = 4I' = I$ …(i)

If one of slit is closed, Resultant intensity at the same point will be I' only *i.e.* $I' = I_O$ …(ii)

Comparing equation (i) and (ii) we get

$I = 4I_O$

13. (b, d) $\frac{I_{max}}{I_{min}} = 9 \Rightarrow \left(\frac{a_1+a_2}{a_1-a_2}\right)^2 = 9 \Rightarrow \frac{a_1+a_2}{a_1-a_2} = 3$

$\Rightarrow \frac{a_1}{a_2} = \frac{3+1}{3-1} \Rightarrow \frac{a_1}{a_2} = 2.$ Therefore $I_1 : I_2 = 4:1$

14. (b)

15. (c) Distance of n^{th} bright fringe $y_n = \frac{n\lambda D}{d}$ i.e. $y_n \propto \lambda$

$\therefore \frac{x_{n_1}}{x_{n_2}} = \frac{\lambda_1}{\lambda_2} \Rightarrow \frac{x(\text{Blue})}{x(\text{Green})} = \frac{4360}{5460}$

$\therefore x$ (Green) > x (Blue).

16. (c) $\beta = \frac{\lambda D}{d} = \frac{5000 \times 10^{-10} \times 1}{0.1 \times 10^{-3}} m = 5 \times 10^{-3} m = 0.5\ cm.$

17. (a) We know that fringe width $\beta = \frac{D\lambda}{d}$

$\therefore x = \frac{L\lambda}{d} \Rightarrow \lambda = \frac{xd}{L}$

18. (a) In the normal adjustment of young's, double slit experiment, path difference between the waves at central location is always zero, so maxima is obtained at central position.

19. (a) $\beta = \frac{\lambda D}{d}$; $\therefore B \propto \lambda$

$\frac{\lambda'}{\lambda} = \frac{0.4}{4/3} \Rightarrow \lambda' = 0.3\ mm.$

20. (b) $\beta \propto \lambda,\ \therefore \lambda \propto \frac{1}{\mu}$

21. (a) $\beta \propto \lambda,\ \therefore \lambda_v =$ minimum.

22. (c) $\beta_{\text{medium}} = \frac{\beta_{\text{air}}}{\mu} = \frac{0.6}{1.5} = 0.4\ mm.$

23. (d) $\because n = 3,\ \therefore 2n\pi = 2 \times 3\pi = 6\pi$

24. (c) Slit width ratio $= 4:9$; hence $I_1 : I_2 = 4:9$

$\therefore \frac{a_1^2}{a_2^2} = \frac{4}{9} \Rightarrow \frac{a_1}{a_2} = \frac{2}{3}$

$\therefore \frac{I_{\max}}{I_{\min}} = \frac{(a_1+a_2)^2}{(a_1-a_2)^2} = \frac{25}{1}$

25. (d) $\beta = \frac{\lambda D}{d} \Rightarrow d = \frac{\lambda D}{\beta} = \frac{6000 \times 10^{-10} \times (40 \times 10^{-2})}{0.012 \times 10^{-2}} = 0.2\ cm$

26. (a) As $\beta = \frac{D\lambda}{d} \Rightarrow \frac{\beta_1}{\beta_2} = \left(\frac{D_1}{D_2}\right)\left(\frac{\lambda_1}{\lambda_2}\right)\left(\frac{d_2}{d_1}\right)$

$\Rightarrow 1 = \left(\frac{D_1}{D_2}\right) \times \left(\frac{1}{2}\right) \times \left(\frac{1}{2}\right) \Rightarrow \frac{D_1}{D_2} = \frac{4}{1}$

27. (b)

28. (c) Fringe width $(\beta) = \frac{D\lambda}{d} \Rightarrow \beta \propto \lambda$

As $\lambda_{\text{red}} > \lambda_{\text{yellow}}$, hence fringe width will increase.

29. (d) $\beta = \frac{\lambda D}{d} \Rightarrow \frac{\beta_2}{\beta_1} = \frac{\lambda_2 D_2 d_1}{\lambda_1 D_1 d_2} \Rightarrow \beta_2 = 2.5 \times 10^{-4} m.$

30. (d) For interference, λ of both the waves must be same.

31. (d) $\beta \propto D$

32. (a) $\theta = \frac{\lambda}{d}$; θ can be increased by increasing λ, so here λ has to be increased by 10%

i.e., % Increase $= \frac{10}{100} \times 5890 = 589 Å$

33. (b) $d = \frac{D\lambda}{\beta} = \frac{1 \times 5 \times 10^{-7}}{5 \times 10^{-3}} = 10^{-4} m = 0.1\ mm.$

34. (b) If intensity of each wave is I, then initially at central position $I_o = 4I$. when one of the slit is covered then intensity at central position will be I only *i.e.*, $\frac{I_o}{4}$.

35. (a) Shift

$= \frac{\beta}{\lambda}(\mu - 1)\, t = \frac{\beta}{(5000 \times 10^{-10})}(1.5) \times 2 \times 10^{-6} = 2\beta$

i.e., 2 fringes upwards.

36. (b) $\beta = \frac{\lambda D}{d}$

37. (b) Separation n^{th} bright fringe and central maxima is $x_n = \frac{n\lambda D}{d}$

So, $x_3 = \frac{3 \times 6000 \times 10^{-10} \times 1}{0.5 \times 10^{-3}} = 3.5\ mm.$

38. (d) $n_1\lambda_1 = n_2\lambda_2 \Rightarrow 62 \times 5893 = n_2 \times 4358 \Rightarrow n_2 = 84.$

39. (b) Angular fringe width $\theta = \frac{\lambda}{d} \Rightarrow \theta \propto \lambda$

$\lambda_w = \frac{\lambda_a}{\mu_w}$

So $\theta_w = \frac{\theta_{\text{air}}}{\mu_w} = \frac{0.20}{\frac{4}{3}} = 0.15°$

40. (a) By using $x_n = \frac{n\lambda D}{d}$

$\Rightarrow (5 \times 10^{-3}) = \frac{10 \times \lambda \times 1}{(1 \times 10^{-3})} \Rightarrow \lambda = 5 \times 10^{-7} m = 5000 Å$

41. (b) Distance of third maxima from central maxima is

$x = \frac{3\lambda D}{d} = \frac{3 \times 5000 \times 10^{-10} \times (200 \times 10^{-2})}{0.2 \times 10^{-3}} = 1.5\ cm$

42. (d) Distance of n^{th} dark fringe from central fringe

$x_n = \frac{(2n-1)\lambda D}{2d}$

$\therefore x_2 = \frac{(2 \times 2 - 1)\lambda D}{2d} = \frac{3\lambda D}{2d}$

$\Rightarrow 1\times10^{-3} = \frac{3\times\lambda\times1}{2\times0.9\times10^{-3}} \Rightarrow \lambda = 6\times10^{-5}\ cm$

43. (d) $\beta = \frac{\lambda D}{d} \Rightarrow (4\times10^{-3}) = \frac{4\times10^{-7}\times D}{0.1\times10^{-3}} \Rightarrow D = 1\,m$

44. (a) $\beta = \frac{\lambda D}{d} \Rightarrow (0.06\times10^{-2}) = \frac{\lambda\times1}{1\times10^{-3}} \Rightarrow \lambda = 6000\,\mathring{A}$

45. (b)

46. (d) $(n_1\lambda_1 = n_2\lambda_2)\ \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} \Rightarrow \frac{n_1}{92} = \frac{5898}{5461} \Rightarrow n_1 = 99$

47. (d) If we use torch light in place of monochromatic light then overlapping of fringe pattern take place. Hence no fringe will appear.

48. (b)

49. (b) Position of 3rd bright fringe $x_3 = \frac{3D\lambda}{d}$

$\Rightarrow \lambda = \frac{x_3 d}{3D} = \frac{(0.9\times10^{-2})\times(0.28\times10^{-3})}{3\times1.4} = 6000\mathring{A}$

50. (a) Distance between two consecutive

Dark fringes $= \frac{\lambda D}{d} = \frac{6000\times10^{-10}\times1}{0.6\times10^{-3}}$

$= 1\times10^{-3}\,m = 1\,mm.$

51. (b, c) For maxima, path difference $\Delta = n\lambda$

So for n =1, $\Delta = \lambda = 6320\mathring{A}$

52. (b) Shift in the fringe pattern $x = \frac{(\mu-1)t.D}{d}$

$= \frac{(1.5-1)\times2.5\times10^{-5}\times100\times10^{-2}}{0.5\times10^{-3}} = 2.5\ cm$

53. (d) In the presence of thin glass plate, the fringe pattern shifts, but no change in fringe width.

54. (a) $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda$

55. (a) In interference between waves of equal amplitudes *a,* the minimum intensity is zero and the maximum intensity is proportional to $4a^2$. For waves of unequal amplitudes a and $A(A > a)$, the minimum intensity is non zero and the maximum intensity is proportional to $(a + A)^2$, which is greater than $4a^2$.

56. (b) $\beta = \frac{\lambda D}{d} = \frac{6000\times10^{-10}\times2}{4\times10^{-3}} = 3\times10^{4}\,m = 0.3\ mm$

57. (c) $\beta \propto \lambda$

58. (c) $\beta = \frac{\lambda D}{d}$

59. (c) Distance between consecutive bright fringes or dark fringes $= \beta$

$\beta = \frac{\lambda D}{d} = \frac{550\times10^{-9}\times1}{1.1\times10^{-3}} = 500\times60^{-6} = 0.5\ mm$

60. (b) $\frac{I_{max}}{I_{min}} = \frac{\left(\frac{a_1}{a_2}+1\right)^2}{\left(\frac{a_1}{a_2}-1\right)^2} = \frac{4}{1} \Rightarrow \frac{a_1}{a_2} = \frac{3}{1}$

61. (b) $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda$

62. (c)

63. (b) $n_1\lambda_1 = n_2\lambda_2 \Rightarrow n_2 = n_1\times\frac{\lambda_1}{\lambda_2} = 12\times\frac{600}{400} = 18$

64. (d) Using relation, $d\sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n\lambda}{d}$

For n = 3, $\sin\theta = \frac{3\lambda}{d} = \frac{3\times589\times10^{-9}}{0.589}$

$= 3\times10^{-6}$ or $\theta = \sin^{-1}(3\times10^{-6})$

65. (b) $\beta \propto \frac{1}{d}$

66. (a) When white light is used, central fringe will be white with red edges, and on either side of it, we shall get few coloured bands and then uniform illumination.

67. (c) $\beta \propto \frac{\lambda}{d}$

68. (b) $\beta \propto \lambda$

69. (a) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 = \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2 \approx 34$; (given $I_1 = 2I_2$)

70. (b) $B \propto \lambda$

71. (d) $\beta \propto \frac{\lambda}{d}$

72. (b)

73. (b) For dark fringe at P

$S_1P - S_2P = \Delta = (2n-1)\lambda/2$

Here n =3 and λ = 6000

So, $\Delta = \frac{5\lambda}{2} = 5\times\frac{6000}{2} = 15000\mathring{A} = 1.5\ micron$

74. (b) Distance of n^{th} minima from central bright fringe

$x_n = \frac{(2n-1)\lambda D}{2d}$

For n=3 *i.e.* 3rd minima

$x_3 = \frac{(2\times3-1)\times500\times10^{-9}\times1}{2\times1\times10^{-3}}$

$= \frac{5\times500\times10^{-6}}{2} = 1.25\times10^{-3}\,m = 1.25\ mm.$

75. (c) $\beta = \frac{\lambda D}{d}$ and $\lambda \propto \frac{1}{\mu}$

76. (d) $n_1\lambda_1 = n_2\lambda_2 \Rightarrow 3\times 700 = 5\times\lambda_2 \Rightarrow \lambda_2 = 420\,nm$

77. (a) $\beta \propto \frac{\lambda}{d}$ as $d \to \frac{d}{3}$ so $\beta \to 3\beta$ $\therefore n = 3$

78. (c) If shift is equal to n fringes width, then

$$n = \frac{(\mu-1)t}{\lambda} = \frac{(1.5-1)\times 2\times 10^{-6}}{500\times 10^{-9}} = \frac{1}{500}\times 10^3 = 2$$

Since a thin film is introduced in upper beam. So shift will be upward.

79. (b) Distance between n^{th} Bright fringe and m^{th} dark fringe $(n > m)$

$$\Delta x = \left(n - m + \frac{1}{2}\right)\beta = \left(5 - 3 + \frac{1}{2}\right)\times\frac{6.5\times 10^{-7}\times 1}{1\times 10^{-3}}$$

$= 1.63\,mm$

80. (a) $\beta = \frac{\lambda D}{d}$; If λ and d both increase by 10%, there will be no change in fringe width (β).

81. (b) $\frac{I_1}{I_2} = \frac{1}{4} \Rightarrow I_1 = k$ and $I_2 = 4k$

$\therefore$ Fringe visibility $V = \frac{2\sqrt{I_1 I_2}}{(I_1 + I_2)} = \frac{2\sqrt{k\times 4k}}{(k+4k)} = 0.8$

82. (b) $\frac{I_{max}}{I_{min}} = \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2 = \left(\frac{3a+a}{3a-a}\right)^2 = \frac{4}{1}$

83. (d) Angular position of first dark fringe

$\theta = \frac{\lambda}{d} = \frac{5460\times 10^{-10}}{0.1\times 10^{-3}}\times\frac{180}{\pi}$ (in degree)

$= 0.313°$

84. (a) Distance between two consecutive dark fringes $\beta = \frac{\lambda D}{d} = \frac{5000\times 10^{-10}\times 1}{0.2\times 10^{-2}} = 0.25\,mm.$

85. (a) If thin film appears dark

$2\mu t\cos r = n\lambda$ for normal incidence $r = 0^o$

$\Rightarrow 2\,\mu\, t = n\lambda \Rightarrow t = \frac{n\lambda}{2\mu}$

$\Rightarrow t_{min} = \frac{\lambda}{2\mu} = \frac{5890\times 10^{-10}}{2\times 1} = 2.945\times 10^{-7}\,m.$

86. (b) In case of destructive interference (minima) phase difference is odd multiple of π.

87. (b) $\beta = \frac{(a+b)\lambda}{2a(\mu-1)\alpha}$

where a = distance between source and biprism = 0.3 m

b = distance between biprism and screen = 0.7 m.

α = Angle of prism = 1°, μ = 1.5, λ = 6000 $\times 10^{-10}\,m$

Hence, $\beta = \frac{(0.3+0.7)\times 6\times 10^{-7}}{2\times 0.3(1.5-1)\times(1^o\times\frac{\pi}{180})}$

$= 1.14\times 10^{-4}\,m = 0.0114\,cm.$

88. (d) For minima, path difference $\Delta = (2n-1)\frac{\lambda}{2}$

For third minima $n = 3 \Rightarrow \Delta = (2\times 3 - 1)\frac{\lambda}{2} = \frac{5\lambda}{2}$

89. (b) Fringe width $(\beta) \propto \frac{1}{\text{prism Angle}(\alpha)}$

90. (a) By using

$$\beta = \frac{(a+b)\lambda}{2a(\mu-1)\alpha} = \frac{(0.3+0.7)\times 180\pi\times 10^{-9}}{2\times 0.3(1.54-1)\times\left(1\times\frac{\pi}{180}\right)}$$

$= 10^{-4}\,m$

91. (a) $\because$ $\beta \propto \lambda \Rightarrow \lambda_w < \lambda_a$ so $\beta_w < \beta_a$

92. (c) With white light, the rays reaching the centre has zero path difference. So we get white fringe at the centre and coloured near the central fringe.

93. (a) $\beta_{water} = \frac{\beta_{air}}{\mu_w}$

94. (a) $\beta = \frac{\lambda D}{d}$

95. (b) Lateral displacement of fringes $= \frac{\beta}{\lambda}(\mu - 1)\,t$

$= \frac{1\times 10^{-3}}{600\times 10^{-9}}(1.5-1)\times 0.06\times 10^{-3} = \frac{1}{20}\,m = 5\,cm$

96. (b)

97. (d) Distance of the n^{th} bright fringe from the centre $x_n = \frac{n\lambda D}{d}$

$\Rightarrow x_3 = \frac{3\times 6000\times 10^{-10}\times 2.5}{0.5\times 10^{-3}} = 9\times 10^{-3}\,m = 9\,mm.$

Doppler's Effect of Light

1. (d) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$, Now $\Delta\lambda = \frac{0.5}{100}\lambda \Rightarrow \frac{\Delta\lambda}{\lambda} = \frac{0.5}{100}$

$\therefore v = \frac{0.5}{100}\times c = \frac{0.5}{100}\times 3\times 10^8 = 1.5\times 10^6\,m/s$

Increase in λ indicates that the star is receding.

2. (a) Doppler's shift is given by

$\Delta\lambda = \frac{v\lambda}{c} = \frac{5000\times 6000}{3\times 10^8} = 0.1\mathring{A}$

3. (b) Shifting towards ultraviolet region shows that Apparent wavelength decreased.

Therefore the source is moving towards the earth.

4. (b) Due to expansion of universe, the star will go away from the earth thereby increasing the observed wavelength. Therefore the spectrum will shift to the infrared region.

5. (b) With reference to this theory the velocity of the observer is neglected *w.r.t.* the light velocity.

6. (b) $\frac{\Delta\lambda}{\lambda}=\frac{v}{c}=\frac{6\times10^7}{3\times10^8}=0.2$

$\Delta\lambda=\lambda'-\lambda=0.2\lambda\Rightarrow\lambda'=1.2\lambda=1.2\times4600=5520\mathring{A}$

7. (b) $\Delta\lambda=5200-5000=200\mathring{A}$

Now $\frac{\Delta\lambda}{\lambda'}=\frac{v}{c}\Rightarrow v=\frac{c\Delta\lambda}{\lambda'}=\frac{3\times10^8\times200}{5000}$

$=1.2\times10^7\,m/\sec\approx1.15\times10^7\,m/\sec$

8. (d) $\frac{\Delta\lambda}{\lambda}=\frac{v}{c}\Rightarrow v=\frac{c}{\lambda}\Delta\lambda=\frac{c}{\lambda}(\lambda'-\lambda)=c\times\frac{0.01}{100}$

$=3\times10^4\,m/s=30\,km/\sec$

9. (c) Blue radiations have the wavelength around $4600\,\overset{o}{A}$. It shows that apparent wavelength is smaller than the real wavelength. It means that the star is proceeding towards earth.

10. (c)

11. (a)

12. (c)

13. (b) $\Delta\lambda=\lambda\frac{v}{c}=5700\times\frac{100\times10^3}{3\times10^8}=1.90\mathring{A}$

14. (a) According to Doppler's effect, wherever there is a relative motion between source and observer, the frequency observed is different from that given out by source.

15. (a) $\Delta\lambda=\lambda.\frac{v}{c}=\frac{1.5\times10^6}{3\times10^8}\times5000=25\mathring{A}$

16. (d) $\Delta\lambda=\frac{v}{c}\lambda=\frac{3600\times10^3}{3\times10^8}\times5896=70.75\mathring{A}$

So the increased wavelength of light is observed.

17. (b) Observed frequency $v'=v\left(1-\frac{v}{c}\right)$

$\Rightarrow v'=6\times10^{14}\left(1-\frac{0.8\,c}{c}\right)=1.2\times10^{14}\,Hz$

18. (c) According to Doppler's principle $\lambda'=\lambda\sqrt{\frac{1-v/c}{1+v/c}}$ for $v=c$

$\lambda'=5500\sqrt{\frac{(1-0.8)}{1+0.8}}=1833.3$

$\therefore$ Shift = 5500 – 1833.3 = 3167 Å

19. (b) $\Delta\lambda=\lambda\frac{v}{c}$

$\Rightarrow(3737-3700)=3700\times\frac{v}{3\times10^8}\Rightarrow v=3\times10^6\,m/s$

20. (d) $\Delta\lambda=\frac{v_s}{c}\lambda\Rightarrow v_s=\frac{\Delta\lambda.c}{\lambda}=\frac{47\times3\times10^8}{4700}$

$=3\times10^6\,m/s$ away from earth

21. (b) $\frac{\Delta\lambda}{\lambda}=\frac{v}{c}\Rightarrow\frac{0.05}{100}=\frac{v}{3\times10^8}$ $\Rightarrow v=1.5\times10^5\,m/s$

(Since wavelength is decreasing, so star coming closer)

22. (b)

23. (c) $\lambda'=\lambda\left(1-\frac{v}{c}\right)=5890\left(1-\frac{4.5\times10^6}{3\times10^8}\right)\approx5802$Å

24. (c) $\frac{\Delta\lambda}{\lambda}=\frac{v}{c}\therefore v=\frac{\Delta\lambda}{\lambda}c=\frac{0.1}{6000}\times3\times10^5\,km/s=5\,km/s$

25. (b) $\frac{\Delta\lambda}{\lambda}=\frac{v}{c}\Rightarrow\Delta\lambda=\frac{5700\times10^6}{3\times10^3}=19\mathring{A}$

26. (b) $v'=v\left(1-\frac{v}{c}\right)=4\times10^7\left(1-\frac{0.2c}{c}\right)=3.2\times10^7\,Hz$

27. (c) When the source and observer approach each other, apparent frequency increases and hence wavelength decreases.

28. (b)

29. (a) $\frac{\Delta\lambda}{\lambda}=\frac{v}{c}\Rightarrow1=\frac{v}{c}\Rightarrow v=c$

30. (d)

$\frac{\Delta\lambda}{\lambda}=\frac{v}{c}\Rightarrow v=\frac{\Delta\lambda}{\lambda}.c=\frac{5}{6563}\times(3\times10^8)=2.29\times10^5\,m/sec$

31. (c)

32. (a) Using $\frac{\Delta\lambda}{\lambda}=\frac{v}{c}\Rightarrow v=\frac{\Delta\lambda}{\lambda}c$

$\Rightarrow v=0.004\times3\times10^8=1.2\times10^6\,m/sec$

33. (a)

Diffraction of Light

1. (c) For first minima $\theta=\frac{\lambda}{a}$ or $a=\frac{\lambda}{\theta}$

$\therefore a=\frac{6500\times10^{-8}\times6}{\pi}$ (As $30^o=\frac{\pi}{6}$ radian)

$=1.24\times10^{-4}\,cm=1.24$ microrns

2. (a) The angular half width of the central maxima is given by $\sin\theta = \frac{\lambda}{a}$

$\Rightarrow \theta = \frac{6328\times10^{-10}}{0.2\times10^{-3}}\, rad$

$= \frac{6328\times10^{-10}\times80}{0.2\times10^{-3}\times\pi}\, degree = 0.18^o$

Total width of central maxima $= 2\theta = 0.36^o$

3. (b)

4. (c) It is caused due to turning of light around corners.

5. (c) Width of central maxima $= \frac{2\lambda D}{d}$

$= \frac{2\times2.1\times5\times10^{-7}}{0.15\times10^{-2}} = 1.4\times10^{-3} m = 1.4\ mm$

6. (a) Band width $\propto \lambda$,

$\because \lambda_{blue} < \lambda_{red}$, hence for blue light the diffraction bands becomes narrower and crowded together.

7. (a) Using $d\sin\theta = n\lambda$, for $n = 1$

$\sin\theta = \frac{\lambda}{d} = \frac{550\times10^{-9}}{0.55\times10^{-3}} = 10^{-3} = 0.001\, rad$

8. (a) For single slit diffraction pattern $d\sin\theta = \lambda$ ($d =$ slit width)

Angular width = $2\theta = 2\sin^{-1}\left(\frac{\lambda}{d}\right)$

It is independent of D *i.e.* distance between screen and slit

9. (c) Width of central bright fringe.

$= \frac{2\lambda D}{d} = \frac{2\times500\times10^{-9}\times80\times10^{-2}}{0.20\times10^{-3}} = 4\times10^{-3} m = 4 mm.$

10. (b) Diffraction is obtained when the slit width is of the order of wavelength of EM waves (or light). Here wavelength of X-rays (1-100 Å) is very-very lesser than slit width (0.6 *mm*). Therefore no diffraction pattern will be observed.

11. (a) Multiple focii of zone plate given by $f_p = \frac{r_n^2}{(2p-1)\lambda}$, where $p = 1, 2, 3......$

12. (b) $A = n\pi\, d\lambda \;\Rightarrow nd = \frac{A}{\pi\lambda}$ = constant $\Rightarrow n \propto \frac{1}{d}$ (n = number of blocked HPZ) on decreasing d, n increases, hence intensity decreases.

13. (a) For secondary maxima $d\sin\theta = \frac{5\lambda}{2}$

$\Rightarrow d\theta = d.\frac{x}{D(\approx f)} = \frac{5\lambda}{2}$

$\Rightarrow 2x = \frac{5\lambda f}{d} = \frac{5\times0.8\times10^{-7}}{4\times10^{-4}} = 6\times10^{-3} m = 6 mm$

14. (d) By using $f_p = \frac{r^2}{(2p-1)\lambda}$

For first HPZ $r = \sqrt{f_p\lambda} = \sqrt{0.6\times6000\times10^{-10}}$

$= 6\times10^{-4} m.$

15. (a) $f_1 = \frac{r^2}{\lambda} = \frac{(2.3\times10^{-3})^2}{5893\times10^{-10}} = 9\, m.$

16. (b) $\lambda_{Blue} < \lambda_{Red}$. Therefore fringe pattern will contract because fringe width $\propto \lambda$

17. (a)

18. (a) For diffraction size of the obstacle must be of the order of wavelength of wave *i.e.* $a \approx \lambda$

19. (a) Angular width of central maxima $= \frac{2\lambda}{d}$

$= \frac{2\times589.3\times10^{-9}}{0.1\times10^{-3}} rad \quad = 0.0117\times\frac{180}{\pi} = 0.68°$

20. (d)

21. (a) $r_n = \sqrt{nd\lambda} \Rightarrow r_n \propto \sqrt{n}$

22. (a) $\beta = \frac{\lambda.D}{d}$ w here D = distance of screen from wire, d = diameter of wire

23. (c) Angular width $= \frac{2\lambda}{d} = \frac{2\times6000\times10^{-10}}{12\times10^{-5}\times10^{-2}} = 1\, rad.$

24. (b)

25. (d)

26. (a) $2\theta = \frac{2\lambda}{d}$ (where d = slit width)

As d decreases, θ increases.

27. (d)

28. (d) Distance between the first dark fringes on either side of central maxima = width of central maxima $= \frac{2\lambda D}{d} = \frac{2\times600\times10^{-9}\times2}{1\times10^{-3}} =$ 2.4 *mm*.

29. (b) Thickness of the film must be of the order of wavelength of light falling on film (*i.e.* visible light)

30. (d)

31. (d) For n^{th} secondary maxima path difference

$d\sin\theta = (2n+1)\frac{\lambda}{2} \;\Rightarrow a\sin\theta = \frac{3\lambda}{2}$

32. (d) The phase difference (ϕ) between the wavelets from the top edge and the bottom

edge of the slit is $\phi = \frac{2\pi}{\lambda}(d\sin\theta)$ where d is the slit width. The first minima of the diffraction pattern occurs at $\sin\theta = \frac{\lambda}{d}$ so

$\phi = \frac{2\pi}{\lambda}\left(d \times \frac{\lambda}{d}\right) = 2\pi$

33. (b)

34. (a) For second dark fringe $d\sin\theta = 2\lambda$

$\Rightarrow 24 \times 10^{-5} \times 10^{-2} \times \sin 30 = 2\lambda$

$\Rightarrow \lambda = 6 \times 10^{-7}\ m = 6000\ \mathring{A}$

35. (c) For the first minima $d\sin\theta = \lambda$

$\Rightarrow \sin\theta = \frac{\lambda}{d} \Rightarrow \theta = \sin^{-1}\left(\frac{5000 \times 10^{-10}}{0.001 \times 10^{-3}}\right) = 30^o$

36. (c)

37. (a)

38. (c) Position of first minima = position of third maxima *i.e.*,

$\frac{1 \times \lambda_1 D}{d} = \frac{(2 \times 3 + 1)}{2}\frac{\lambda_2 D}{d} \Rightarrow \lambda_1 = 3.5\lambda_2$

39. (a) Position of nth minima $x_n = \frac{n\lambda D}{d}$

$\Rightarrow 5 \times 10^{-3} = \frac{1 \times 5000 \times 10^{-10} \times 1}{d}$

$\Rightarrow d = 10^{-4}\ m = 0.1\ mm.$

40. (b) Width of n^{th} HPZ $B_n = r_n - r_{n-1}$

$r_n = \sqrt{nb\lambda}$, $r_{n-1} = \sqrt{(n-1)b\lambda}$

$B_n = \sqrt{nb\lambda} - \sqrt{(n-1)b\lambda} = \sqrt{b\lambda}\,[\sqrt{n} - \sqrt{(n-1)}]$

41. (c) In single slit experiment,

Width of central maxima (y) = $2\lambda D / d$

$\Rightarrow \frac{y'}{y} = \frac{\lambda'}{d} \times \frac{d}{\lambda} = \frac{600}{d/2} \times \frac{d}{400} \Rightarrow y' = 3y.$

Polarisation of Light

1. (b) Polariser produced prolarised light.

2. (a) Only transverse waves can be polarised.

3. (c) Polarisation is not shown by sound waves.

4. (d) By using $\mu = \tan\theta_p \Rightarrow \mu = \tan 60 = \sqrt{3}$,

also $C = \sin^{-1}\left(\frac{1}{\mu}\right) \Rightarrow C = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

5. (d) $\mu = \tan\theta_P \Rightarrow \theta_P = \tan^{-1} n$

6. (d) Ultrasonic waves are longitudinal waves.

7. (b) $I = I_0\cos^2\theta = I_0\cos^2 45 = \frac{I_0}{2}$

8. (d)

9. (a) It magnitude of light vector varies periodically during it's rotation, the tip of vector traces an ellipse and light is said to be elliptically polarised. This is not in nicol prism.

10. (c) At polarizing angle, the reflected and refracted rays are mutually perpendicular to each other.

11. (a) When unpolarised light is made incident at polarising angle, the reflected light is plane polarised in a direction perpendicular to the plane of incidence.

Therefore $\vec{E}$ in reflected light will vibrate in vertical plane with respect to plane of incidence.

12. (d) In the arrangement shown, the unpolarised light is incident at polarising angle of 90° – 33° = 57°. The reflected light is thus plane polarised light. When plane polarised light is passed through Nicol prism (a polariser or analyser), the intensity gradually reduces to zero and finally increases.

13. (a)

14. (a) A plane which contains $\vec{E}$ and the propagation direction is called the plane of polarization.

15. (c)

16. (d) Light suffers double refraction through calcite.

17. (d) The amplitude will be $A\cos 60^o = A/2$

18. (d)

19. (b) Rotation produced $\theta = Slc$

Net rotation produced $\theta_r = \theta_1 - \theta_2 = l\,(S_1c_1 - S_2c_2)$

$= 0.29 \times [0.01 \times 60 - 0.02 \times 30] = 0$

20. (c) In double refraction light rays always splits into two rays (O-ray & E-ray). O-ray has same velocity in all direction but E-ray has different velocity in different direction.

For calcite $\mu_e < \mu_0 \Rightarrow v_e > v_0$

For quartz $\mu_e > \mu_0 \Rightarrow v_0 > v_e$

21. (c) $\theta_P + r = 90^\circ$ or $r = 90^\circ - \theta_P = 90^\circ - 53^\circ 4' = 36^\circ 56'$.

22. (d)

23. (a)

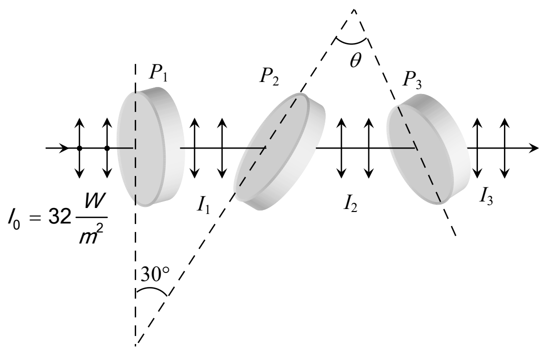
24. (c) Intensity of polarized light from first polarizer $= \frac{100}{2} = 50$

$I = 50\cos^2 60^\circ = \frac{50}{4} = 12.5$

25. (b) $I' = \frac{I}{2}\cos^2\theta = \frac{I}{6}$ or $\cos\theta = \frac{1}{\sqrt{3}}$ $\therefore$ $\theta = 55^\circ$

26. (b) Angle between P_1 and $P_2 = 30^\circ$ (given)

Angle between P_2 and $P_3 = \theta = 90^\circ - 30^\circ = 60^\circ$



The intensity of light transmitted by P_1 is
$I_1 = \frac{I_0}{2} = \frac{32}{2} = 16\frac{W}{m^2}$

According to Malus law the intensity of light transmitted by P_2 is

$I_2 = I_1\cos^2 30^\circ = 16\left(\frac{\sqrt{3}}{2}\right)^2 = 12\frac{W}{m^2}$

Similarly intensity of light transmitted by P_3 is $I_3 = I_2\cos^2\theta = 12\cos^2 60^\circ = 12\left(\frac{1}{2}\right)^2 = 3\frac{W}{m^2}$

27. (b) $\theta = a + \frac{b}{\lambda^2}$

$30 = a + \frac{b}{(5000)^2}$ and $50 = a + \frac{b}{(4000)^2}$

Solving for a, we get $a = -\frac{50^\circ}{9}$ per mm

28. (c) If an unpolarised light is converted into plane polarised light by passing through a polaroid, it's intensity becomes half.

29. (a)

30. (b) The magnitude of electric field vector varies periodically with time because it is the form of electromagnetic wave.

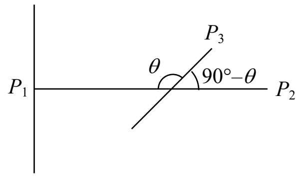
31. (a) According to Brewster's law, when a beam of ordinary light (i.e. unpolarised) is reflected from a transparent medium (like glass), the reflected light is completely plane polarised at certain angle of incidence called the angle of polarisation.

32. (a) When the plane-polarised light passes through certain substance, the plane of polarisation of the light is rotated about the direction of propagation of light through a certain angle.

33. (c) From Brewster's law $\mu = \tan i_p \Rightarrow$ $\frac{c}{v} = \tan 60^\circ = \sqrt{3}$

$\Rightarrow v = \frac{c}{\sqrt{3}} = \frac{3\times 10^8}{\sqrt{3}} = \sqrt{3}\times 10^8\ m/sec.$

34. (a) No light is emitted from the second polaroid, so P_1 and P_2 are perpendicular to each other



Let the initial intensity of light is I_0. So Intensity of light after transmission from first polaroid $= \frac{I_0}{2}$.

Intensity of light emitted from P_3
$I_1 = \frac{I_0}{2}\cos^2\theta$

Intensity of light transmitted from last polaroid *i.e.* from $P_2 = I_1\cos^2(90^o - \theta) = \frac{I_0}{2}\cos^2\theta.\sin^2\theta$

$= \frac{I_0}{8}(2\sin\theta\cos\theta)^2 = \frac{I_0}{8}\sin^2 2\theta$.

35. (d)

EM Waves

1. (a)

2. (d) $\lambda_{Red} > \lambda_{Blue} > \lambda_{X-ray} > \lambda_\gamma$

3. (b) Infrasonic waves are mechanical waves.

4. (d) $\mu_0 = 4\pi \times 10^{-7}, \varepsilon_0 = 8.85 \times 10^{-12} \frac{N\text{-}m^2}{C^2}$

so $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3 \times 10^8 \frac{meter}{sec}$.

5. (b) Wavelength of visible spectrum is 3900 Å – 7800 Å.

6. (b) Infrared causes heating effect.

7. (a)

8. (d)

9. (c) Speed of EM waves in vacuum = $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$ =constant

10. (a) $\lambda_{\gamma-rays} < \lambda_{x-rays} < \lambda_{\alpha-rays} < \lambda_{\beta-rays}$.

11. (a) Distance covered by T.V. signals = $\sqrt{2hR}$

$\Rightarrow$ maximum distance $\propto h^{1/2}$

12. (c) β-rays are beams of fast electrons.

13. (a)

14. (b) Velocity of EM waves

$= \frac{1}{\sqrt{\mu_0 \epsilon_0}} 3 \times 10^8 m/s$=velocity of light

15. (b) Ozone layer absorbs most of the UV rays emitted by sun.

16. (d) $\nu_{\gamma-rays} > \nu_{\text{visible radiation}} > \nu_{\text{Infrared}} > \nu_{\text{Radio waves}}$

17. (b) Infrared radiations reflected by low lying clouds and keeps the earth warm.

18. (d) $\lambda_{Radiowaves} > \lambda_{UV\ rays} > \lambda_{J\ Rays} > \lambda_{X-rays}$

19. (a) Polarization is shown by only transverse waves.

20. (c) EM waves travels with perpendicular to E and B. Which are also perpendicular to each other $\vec{v} = \vec{E} \times \vec{B}$

21. (a)

22. (d) Ozone hole is depletion of ozone layer in stratosphere because of gases like CFC'S etc.

23. (c)

24. (b)

25. (a) $\nu_{\gamma-rays} > \nu_{X-rays} > \nu_{UV-rays}$

26. (a) In vacuum velocity of all EM waves are same but their wavelengths are different.

27. (c)

28. (c)

29. (a) $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{8.2 \times 10^6} = 36.5\ m$

30. (b) $c = \frac{E}{B} \Rightarrow B = \frac{E}{c} = \frac{18}{3 \times 10^8} = 6 \times 10^{-8}\ T$.

31. (c) According to the Maxwell's EM theory, the EM waves propagation contains electric and magnetic field vibration in mutually perpendicular direction. Thus the changing of electric field give rise to magnetic field.

32. (a) Here $E_0 = 100\ V/m,\ B_0 = 0.265\ A/m$.

$\therefore$ Maximum rate of energy flow $S = E_0 \times B_0$

$= 100 \times .265 = 26.5 \frac{W}{m^2}$

33. (d) $E = \frac{hc}{\lambda} = \frac{6.6 \times 10^{-34} \times 3 \times 10^8}{21 \times 10^{-2}} = 0.94 \times 10^{-24} \approx 10^{-24}\ J$

34. (a) $\nu = \frac{C}{\lambda} \Rightarrow \nu_1 = \frac{3 \times 10^8}{1} = 3 \times 10^8\ Hz = 300\ MHz$

and $\nu_2 = \frac{3 \times 10^8}{10} = 3 \times 10^7\ Hz = 30\ MHz$

35. (d)

36. (c) $\vec{E}$ and $\vec{B}$ are mutually perpendicular to each other and are in phase i.e. they become zero and minimum at the same place and at the same time.

37. (b) Molecular spectra due to vibrational motion lie in the microwave region of EM-spectrum. Due to Kirchhoff's law in spectroscopy the same will be absorbed.

38. (a) E_x and B_y would generate a plane EM wave travelling in z-direction. $\vec{E}$, $\vec{B}$ and $\vec{k}$ form a right handed system $\vec{k}$ is along z-axis. As $\hat{i} \times \hat{j} = \hat{k}$

$\Rightarrow E_x \hat{i} \times B_y \hat{j} = C\hat{k}$ *i.e.* E is along x-axis and B is along *y-axis*.

39. (a) $\nu_{\gamma-rays} > \nu_{UV\text{-rays}} > \nu_{\text{Blue light}} > \nu_{\text{Infrared rays}}$

40. (d) Ground wave and sky wave both are amplitude modulated wave and the amplitude modulated signal is transmitted by a transmitting antenna and received by the receiving antenna at a distance place.

41. (a)

42. (b) EM waves transport energy, momentum and information but not charge. EM waves are uncharged

43. (b) EM waves carry momentum and hence can exert pressure on surfaces. They also

transfer energy to the surface so $p \neq 0$ and $E \neq 0$.

44. (c) The angular wave number $k = \frac{2\pi}{\lambda}$; where λ is the wave length. The angular frequency is $w = 2\pi\nu$.

The ratio $\frac{k}{\omega} = \frac{2\pi/\lambda}{2\pi\nu} = \frac{1}{\nu\pi} = \frac{1}{c} =$ constant

45. (a) $\frac{E_0}{B_0} = C$. also $k = \frac{2\pi}{\lambda}$ and $\omega = 2\pi\nu$

These relation gives $E_0 K = B_0 \omega$

46. (b) $\nu = \frac{1}{2\pi\sqrt{LC}}$ and $\lambda = \frac{C}{\nu}$

47. (a) $I = \frac{1}{2}\varepsilon_0 C E_0^2$

$\Rightarrow E_0 = \sqrt{\frac{2I}{\varepsilon_0 C}} = \sqrt{\frac{2 \times 5 \times 10^{-16}}{8.85}} = 0.61 \times 10^{-6} \frac{V}{m}$

Also $E_0 = \frac{V_0}{d}$ $\Rightarrow$

$V_0 = E_0 d = 0.61 \times 10^{-6} \times 2 = 1.23 \mu V$

48. (c)

49. (c) Population covered = $2\pi hR$ × Population density

$= 2\pi \times 100 \times 6.4 \times 10^6 \times \frac{1000}{(10^3)^2} = 4 \times 10^6$

50. (a)

51. (c)

52. (c) Refractive index $= \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$

Here μ is not specified so we can consider $\mu = \mu_0$

then refractive index $= \sqrt{\frac{\varepsilon}{\varepsilon_0}} = 2$

$\therefore$ Speed and wavelength of wave becomes half and frequency remain unchanged.

53. (d)

54. (d)

55. (b)

56. (b)

57. (a) Intensity or power per unit area of the radiations $P = f\nu \Rightarrow$

$f = \frac{P}{v} = \frac{0.5}{3 \times 10^8} = 0.166 \times 10^{-8} \; N/m^2$

58. (d) $v = \frac{c}{\sqrt{\mu_r \varepsilon_r}} = \frac{3 \times 10^8}{\sqrt{1.3 \times 2.14}} = 1.8 \times 10^8 \; m/sec$

59. (b) $I' = Ie^{-\mu x} \Rightarrow x = \frac{1}{\mu}\log_e \frac{I}{I'}$ (where I = original intensity, I' = changed intensity)

$36 = \frac{1}{\mu}\log_e \frac{I}{I/8} = \frac{3}{\mu}\log_e 2$ ....(i)

$x = \frac{1}{\mu}\log_e \frac{I}{I/2} = \frac{1}{\mu}\log_e 2$ .....(ii)

From equation (i) and (ii), $x = 12\,mm$.

60. (c) $\lambda_m > \lambda_v > \lambda_x$

61. (a) If maximum electron density of the ionosphere is N_{max} per m^3 then the critical frequency f_c is given by $f_c = 9(N_{max})^{1/2}$.

$\Rightarrow 1 \times 10^6 = 9(N)^{1/2} \Rightarrow N = 1.2 \times 10^{12} \; m^{-3}$

62. (c)

63. (b)

64. (a)

65. (c)

66. (d) Direction of wave propagation is given by $\vec{E} \times \vec{B}$.

67. (c) Speed of light of vacuum $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ and in another medium $v = \frac{1}{\sqrt{\mu\varepsilon}}$

$\therefore \frac{c}{v} = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}} = \sqrt{\mu_r K} \Rightarrow v = \frac{c}{\sqrt{\mu_r K}}$