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Fundamentals of fiber waveguide modes

("Self Test")

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Dear participant,

Find below some multiple choice questions based on the material covered during the lectures. They are meant to bring out further features of modes in optical waveguides and for self evaluation. Enjoy yourself.

Self test

1. A bare silica fiber having a refractive index of 1.45 has air as the cladding. The maximum angle of acceptance of the fiber would be
   a) less than 90^o
   b) equal to 90^o
   c) greater then 90^o
2. The acceptance angle of an optical fiber placed in air is 12^o. When the fiber tip is immersed in water, the acceptance angle of the fiber will
   a) increase
   b) decrease
   c) remain same
3. An optical fiber has core and cladding refractive indices of 1.45 and 1.44 respectively. State which of the following effective indices correspond to guided modes, radiation modes and which are not allowed
   a) 1.446
   b) 1.449
   c) 1.43
   d) 1.46
4. A planar optical waveguide supports two only guided TE modes with effective indices 1.5024 and 1.5007 at a wavelength of 1000 nm. State whether the following statements are true or false:
   a) The number of guided TE modes will increase as we increase the wavelength
   b) The number of guided TE modes will increase as we increase the width of the waveguide
   c) The mode with effective index 1.5007 has a greater penetration depth into the cladding than the other mode.
   d) The mode with the higher effective index corresponds to TE_1 mode
5. In continuation of Q.4, if the core index of the waveguide is 1.503 and the cladding index is 1.500, then the angle subtended with the *z*-axis (the propagation direction) by the plane waves corresponding to the fundamental mode is
   a) 1.619^o
   b) 3.239^o
   c) 88.381^o

d) 86.761^{o}

6. An optical fiber supports only two guided modes namely LP_{01} and LP_{11} modes. Light is launched so that both modes have equal power at the input. Assuming no attenuation, if fiber is ideal then which of the following statements are correct?
    a) The power will flow from one mode to the other periodically along the length
    b) The powers in individual modes will remain constant with distance
    c) The power from LP_{11} mode will flow into the LP_{01} mode
    d) The transverse intensity pattern will vary with distance
7. A depressed clad optical fiber consists of three regions: region between $r = 0$ and a has a refractive index n_1, region between $r = a$ and b ($> a$) has a refractive index n_3 and the region beyond $r = b$ has a refractive index n_2 with $n_1 > n_2 > n_3$. Which of the following conditions defines loss less guided modes?
    a) $n_1 > n_{eff} > n_3$
    b) $n_2 > n_{eff} > n_3$
    c) $n_1 > n_{eff} > n_2$
8. An optical fiber with an attenuation coefficient of 0.2 dB/km is 100 km long. If the input power is 1 mW, then the power coming out of the fiber would be
    a) 100 μW
    b) 10 μW
    c) 1 μW
9. An optical fiber communication system has two splices each with a loss of 0.1 dB, two connectors each with a loss of 0.9 dB. If the fiber used in the system has an attenuation coefficient of 0.28 dB/km, then the maximum permissible length so that the output power is at least 10 μW when the input power is 10 mW is
    a) 10 km
    b) 100 km
    c) 104 km
    d) 200 km
10. Silica optical fibers have lowest loss at a wavelength of
    a) 850 nm
    b) 1000 nm
    c) 1310 nm
    d) 1550 nm
11. A single mode fiber has a cut off of 1250 nm. It will be single moded
    a) only at 1250 nm
    b) at all wavelengths below 1250 nm
    c) at all wavelengths above 1250 nm
12. Two fibers have the same cut off wavelength of 1200 nm. The fiber with a higher refractive index difference would have
    a) larger core radius
    b) smaller core radius
    c) same core radius as the other
13. Two single mode optical fibers have identical core radii but different N.A. Which of the following statements are true?
    a) Both fibers will have the same spot size
    b) Fiber having a larger N.A. would have larger spot size.

c) Fiber having a larger N.A. would have smaller spot size

14. Consider the joint between two perfectly aligned single mode fibers with Gaussian spot sizes of 5 μm (fiber # 1) and 5.2 μm (fiber # 2). Which of the following statements are true?
    a) There would be no loss at the joint
    b) The loss will be less if the input fiber is fiber #1.
    c) The loss will be less if the input fiber is fiber #2.
    d) The loss will be the same whether the input fiber is fiber # 1 or fiber #2.
15. The Gaussian spot size of a given fiber
    a) increases with increase in wavelength
    b) decreases with increase in wavelength
    c) is independent of wavelength
16. By increasing the Gaussian spot size of a single mode fiber
    a) it is possible to increase the tolerance to both transverse and angular misalignment
    b) the tolerance to transverse misalignment would reduce while that for angular misalignment would increase
    c) the tolerance to transverse misalignment would increase while that for angular misalignment would reduce
17. Material dispersion in silica optical fibers becomes zero at around
    a) 850 nm
    b) 1270 nm
    c) 1310 nm
    d) 1550 nm
18. A Gaussian pulse of width 100 ps broadens to a pulse of width 120 ps in traveling through an optical fiber.
    a) both the input and output pulses have the same spectral width
    b) the input pulse has a broader spectrum compared to the output pulse
    c) the output pulse has a broader spectrum compared to the input pulse
19. At the zero dispersion wavelength of an optical fiber,
    a) both group and phase velocities are independent of wavelength
    b) phase velocity is independent of wavelength
    c) group velocity is independent of wavelength
    d) group velocity increases linearly with wavelength
20. Consider two single mode optical fibers with dispersion coefficients of +2 ps/km-nm (fiber # 1) and –2 ps/km-nm (fiber # 2) at a wavelength of 1550 nm. When a light pulse at 1550 nm propagates through the two fibers then
    a) pulse will get compressed while propagating through fiber # 2
    b) pulse will get broadened in both cases but broadening will be less for fiber # 2.
    c) pulse will get broadened in both cases with equal broadening
21. A low power Gaussian pulse (with a spectral width 0.01 nm) propagates through a link fiber of length 100 km consisting of two fiber sections; the first section is of length 75 km with a dispersion coefficient of +16 ps/km-nm and the second section is 25 km long with a dispersion coefficient of –25 ps/km-nm. The net dispersion suffered by the pulse would be
    a) the same irrespective of which fiber section is placed first

b) would be less if the positive dispersion fiber is placed first
c) would be less if the negative dispersion fiber is placed first

22. Consider a hypothetical medium with a propagation constant given by $k = (\omega / c)\, n$ with n being independent of frequency. A Gaussian pulse propagating through such a medium
    a) will not undergo any dispersion or chirping
    b) will undergo dispersion and chirping
    c) will not undergo dispersion but will undergo chirping
23. When an unchirped Gaussian beam propagates through an optical fiber having a negative finite value of β_2 then
    a) pulse will undergo compression
    b) pulse will undergo broadening
    c) pulse will propagate unchanged
24. While propagating through an optical fiber
    a) Broader pulses will undergo greater broadening
    b) Broadening will be same for narrow or broad pulses
    c) narrower pulses will undergo greater broadening
25. In a directional coupler, the coupling of power between the two waveguides is due to
    a) the coupling of power between the symmetric and antisymmetric modes of the coupler
    b) the interference between the symmetric and antisymmetric modes of the coupler
    c) both coupling and interference among the symmetric and antisymmetric modes of the coupler

Answers to the multiple choice questions

1. (b)
2. (b)
3. (a): guided mode; (b): guided mode; (c): radiation mode; (d): not allowed
4. (a): false; (b): true; (c): true; (d): false
5. (a)
6. (b) and (d) are correct
7. (c)
8. (b)
9. (b)
10. (d)
11. (c)
12. (b)
13. (c)
14. (d)
15. (a)
16. (c)
17. (b)
18. (a)
19. (c)
20. (c)
21. (a)
22. (a)
23. (b)
24. (c)
25. (b)