Informal Quiz (SOLUTIONS)
Reading Assignment & Quick Questions

Reading assignments: carefully review slide sets 11,12; Read Chap 1,2,3 of Ramaswami/Sivarajan’s book.
Then answer the following quick true/false questions that test your knowledge.
(Tick (✓) the appropriate boxes on the left)

T  F

☐  ✓  Optical signals cannot cross each other without distortion
☐  ✓  TEM waves are characterized by their phase and propagation speed.
☐  ✓  Different wavelengths of light travel at the same speed in matter
✓  ☐  Reflectivity affects the polarization but not the phase of reflected optical light
✓  ☐  The cladding always has a higher refractive index than the core of a fiber
✓  ☐  Ray optics is the limit of wave optics when the wavelength is very small
☐  ✓  As a monochromatic light propagates through media having different refractive indices the velocity remains the same however the frequency varies
✓  ☐  In polychromatic light the diffraction of the light depends on its wavelength
✓  ☐  Speckle patterns vary rapidly with time however the energy and power are conserved
☐  ✓  The bit rate achievable in multimode fibers is primarily limited by chromatic dispersion

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Single mode fiber eliminates delay spread from all sources

Signal degradation due to chromatic dispersion is inversely proportional to the data-rate

Graded index multimode fibers offer higher bit rates than single mode fibers for shorter distances

Different spectral components of the same pulse travel at the same speed in single-mode fiber, which is why it is called “single” mode

Negative pulse chirping worsens the pulse broadening effects

For certain chirping patterns and GVD parameters the chirped pulses may compress in time, and expand after traveling some distance

Dispersion shifted fibers help reduce the material dispersion

Dispersion shifted fiber (DSF) tackle both the chromatic and the non-linear effects like four-wave mixing

Polarization refers to the direction of the electric field vector

A birefringent crystal has different refractive indices in different directions

The pump wave gains power as it propagates in fiber

In Stimulated Raman Scattering, the Stokes wave is a wave of shorter wavelength propagating only in the reverse direction

The SRS effect itself can be used to create high powered lasers at an appropriate wavelength from lower wavelengths

In case of SBS effect, the Stokes wave propagates in the forward direction

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Higher order solitons are family of pulses that undergo no changes in shape as their propagate through fiber.

Solitons are created through the interaction of carefully shaped pulses with fiber effects such as chromatic dispersion and self-phase modulation.

The conservation of energy constraint says that the electric fields at two outputs of an optical coupler cannot have the same magnitude.

Isolators allow bi-directional transmission.

Faraday rotators can rotate the polarization of the incoming light.

Optical Filters are based upon phenomena such as interference or diffraction.

Transmission gratings have narrow slits whereas reflection gratings have narrow reflection surfaces.

Long period fiber gratings are used to provide gain compensation.

Energy after grating interaction is reflected back in the reverse-direction in a Long Period fiber grating.

Fabry - Perot filters are cavity-based devices where the filtering is done by superposition of partially transmitted waves with other partially transmitted waves that are phase shifted due to repeated reflections within the cavity.

An F-P filter with low reflectivity cavity walls is a laser.

TFMF is an FP etalon where mirrors are realized using a multiple reflective dielectric thin-film layers.

In a Mach- Zehnder Inferometer, the light signal is split into copies, and the copies of the signal are phase shifted and combined.
Isolators are in general polarization-independent devices

Only the wavelength that satisfy the Bragg condition are strongly reflected in a bragg grating

An apodized Bragg grating would have a significant suppression of sidelobes in the spectral response, but a broader main lobe

Circulators in combination with Bragg Gratings can be used to construct OADMs

Chirped fiber bragg gratings can be used to provide compensation for chromatic dispersion, in addition to filtering

Arrayed waveguide gratings are superior to basic M-Z interferometers for larger-scale multiplexing/demultiplexing operation

Acousto-optic effects can be used to create tunable filter, or dynamic wavelength cross-connects

Multi-stage interleaving can be used to build large multiplexors with several components that have only wider spectral responses

A 3R regeneration device is transparent to electrical modulation characteristics

A 2R regeneration device is cannot compensate for timing drifts

An all-optical amplifier is largely transparent to bit rates, number of wavelengths and modulation formats

An EDFA has a larger gain spectrum than a Raman optical amplifier

An EDFA has a larger gain coefficient than a Raman optical amplifier

The EDFA works using the principle of stimulated emission and by creating a population inversion in the appropriate high energy level

The purpose of the pump laser in both EDFA and Raman amplifier is the same: to create a population inversion at the appropriate high energy level
Spontaneous emission is called coherent because has the same wavelength as the signal spectrum being amplified in an EDFA

ASE refers to the noise caused by the amplification of spontaneous emission

The purpose of erbium ion doping is to create energy bandgaps corresponding to 1550nm using the phenomenon called Stark splitting

The reason EDFAs have non-uniform gain and amplify a spectrum of wavelengths (rather than a single wavelength) is because there is a some non-uniformity and spread in the ion distribution around the energy levels

Population inversion refers to the situation where there are more charge carriers in the lower energy level compared to the higher energy level

Population inversion sets the stage for persistent stimulated emission triggered by the optical signal

Stimulated emission leads to a charge carrier going from a higher to a lower energy level, and releasing a photon coherent with the stimulating photon

Longer wavelength correspond to smaller energy photons and smaller bandgap

The spontaneous emission lifetime at the desired higher energy level (eg: E2 in EDFA fibers) should be extremely short, especially compared to the immediately higher energy level (eg: E3)

The process of “pumping” in EDFAs is created by a combination of absorption (charge carriers jumping from E1 to E3), short lifetime in E3, release of a phonon to jump from E3 to E2.

980 nm pumps can be used remotely, as far as 100 miles away from the amplification site

Gain flattening in EDFA is done by wavelength-selective attenuation (achieved using components like long-period in-fiber gratings)
- Counter pumping refers to pumping in a direction reverse of the flow of information.
- Raman amplification in ultra-long-haul systems is done over the lengths of fiber between two EDFAs to complement the gain offered by EDFA.
- A key difference between mere optical amplification and lasing is the need to develop sufficient positive feedback within the cavity.
- An MLM laser outputs a single longitudinal mode, with a tight spectral width.
- Wavelength drift in a laser is undesirable because it would be exacerbated by chromatic dispersion and would conflict with tight DWDM channel spacing needs.
- Unlike LEDs, lasers display a non-linear relationship between drive current and output power.
- Coherence refers to two photons having the same wavelength.
- Double heterojunctions are useful to trap a lower bandgap material (where the lasing or LED action takes place) between two higher bandgap materials.
- The spectral width (of a laser or LED) is less of an issue in free-space-communications (compared to fiber communications) because the refractive index of atmosphere is close to 1.
- A laser output power spectrum plot (especially MLM lasers) may have several lines with short line widths that correspond to the various resonant frequencies of the cavity used.
- An MLM laser may be converted into a SLM laser either by making the cavity length very small (eg: VCSEL design), or by using external cavities or gratings to filter the extra lines.
- An index-guided laser better localizes the output power of a laser.
- The word “mode” means the same thing in the context of lasers (eg: MLM vs SLM) and fibers (multimode vs single-mode).
- If the bragg gratings are present outside the laser gain region, it is called a DBR laser.
- VCSELs at long wavelengths (eg: 1550 nm) have been harder to make partly because of heat dissipation issues.

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<th>VCSELs are easier to manufacture in bulk than regular lasers</th>
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<td>Tunability in lasers is achieved by having sections where the gain, phase and filter wavelength may be separately tuned</td>
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<td>A photo-detector is essentially a positively biased PN junction</td>
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<td>A PIN design is superior to a PN design because the intrinsic (I) region can be made larger.</td>
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<td>Responsivity of detectors in general decreases with increases in wavelength and the quantum efficiency respectively.</td>
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<td>A photodiode is more efficient than a photoconductor because fewer electrons recombine into holes after being created by the impinging photon</td>
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<td>An avalanche photodiode has a gain region where the electrons are accelerated to knock off other electrons, creating a multiplier effect</td>
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<td>NRZ modulation requires higher bandwidth than RZ modulation</td>
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