ECE/OPTI 487/587
Review Summary

Fiber Properties:
- TIR, critical angle, NA, V#, mode propagation angles
- Gaussian beam propagation – beam waist expansion, transformation by a lens, power within a collection radius
- Planar waveguides – TE and TM modes, cut-off wavelengths
- Cylindrical waveguides – TE, TM, HE, EH, and LP modes; mode field diameter, power in the core and cladding
- Fiber coupling – lateral, longitudinal, and angular misalignment for MM, SM, and GI fiber, combinations of losses
- Source-fiber coupling – Gaussian beam, Lambertian beam

Lasers:
- Fundamental processes – absorption, stimulated emission, spontaneous emission
- Laser components – medium, pump, resonators
- Threshold conditions for lasing – gain and phase, longitudinal modes
- RIN noise

Detectors:
- Detection efficiency, responsivity, $\lambda_{\text{max}}$, and $E_{\text{BG}}$
- PIN and APD photodiode
- Frequency response properties – diffusion and drift times, junction capacitance
- Circuit model for detectors
- High impedance and transimpedance amplifiers
- $B_{3\text{dB}}$ and rise time
- Thermal and shot noise, electrical and optical SNR
- Probability of error – BER
- Large photon number conditions – Gaussian statistics, decision level, Q parameter, BER vs. Q, Relation of Q to SNR under different conditions
- Minimum received optical power for a specified BER
- Quantum limit of detection for few photons/bit
- Effect of non-zero, 0-bit power – extinction ratio

Dispersion
- Modal dispersion in MMF.
- Phase and group velocity concepts
- Group velocity, GVD
- Refractive index, effective refractive index, group refractive index.
- Dispersion parameter and its relation to effective index, BL product, b-parameter, $\Delta$
f. Material dispersion and the Sellmeier equation; Derivation of $D_M$ relation with $\lambda^2 \frac{d^2 \tilde{n}}{d\lambda^2}$ and using Figures 3.7 and 3.8

g. Waveguide dispersion; derivation of $D_W$ using $\nu \frac{d^2 (Vb)}{dV^2}$ and Figures 3.9 and 3.10.

h. Polarization mode dispersion.

**Optical Amplifiers:**
- Basic optical amplifiers with emphasis on EDFA’s
- Energy band structure of EDFA’s- pump and emission bands, loss/gain profiles
- Gain coefficient $g(\omega)$, resonance, saturation, spectral BW of gain coefficient
- Amplification factor $G(\omega)$, affect on power after propagating through gain medium, spectral BW of $G(\omega)$ and relation to $g(\omega)$
- Limit on output power due to saturation
- Noise figure and noise power
- SNR for EDFA used as a Rx pre-amp, spon-spon and sign-spon noise factors

**System Analysis:**
- Modulation formats – RZ, NRZ
- Definition of Spectral Efficiency (b/s)/Hz, channel capacity
- Basic principles of WDM, channel spacing, multiplexers/demultiplexers
- Channel analysis – fiber loss, receiver sensitivity, power penalty
- Basic power and rise-time budgets
- Cascaded optical amplifiers
  - Gain saturation
  - Steady state gain and power output

**Fiber Sensors:**
- Basic sensor parameters, measurand and environmental sensitivity, dynamic range, limits imposed by receiver noise
- Analysis of absorption sensors
- Coherence of optical sources, visibility, mutual degree of coherence of a 2 mode source.
- Optical coupler properties
- Analysis of interferometric sensors, matrix description of an interferometer, biasing for optimum sensitivity, minimum sensitivity imposed by detector noise.