NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3550 | MIDTERM EXAM II | 5/00 Prof. Powers

- This exam is closed book and notes; notes on four sides of 8-1/2 x 11 paper are allowed.
- There is a 50 minute time limit.
- There are three problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be *sure* to include units in your answers.
- Please circle or underline your answers.
- Do *NOT* do any work on this sheet.
- Show *ALL* work.

1	
2	
3	
Total	

Name: ______________________________

1. A vertical-cavity surface-emitting laser (VCSEL), operating at 850 nm, has a circular beam pattern with a full-angle beam-divergence of 30°. The diameter of the lasing region is 6 μm and the index of refraction of the lasing material is 3.50. After the laser is made but before adding a fiber pigtail, the power out of the laser is measured to be 10 mW. After six months of operation, the power out of the laser is measured as 9.80 mW.

   The laser is then connected via "butt coupling" to a fiber pigtail. (There is a small air-gap between the source and the pigtail.) The pigtail is 9/125 step-index, singlemode fiber with a core index of 1.460 and $\Delta = 0.1\%$. Calculate the expected power in the fiber pigtail after 20 years of operation.

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2. Consider an avalanche photodiode with a responsivity of 0.5 (at $M = 1$ and $\lambda = 1550$ nm), an excess noise factor of $\mathrm{M}^{0.7}$, a bulk dark current of 1.0 nA, and a surface dark current of 0.5 nA. It is to operate with a load resistor of 50 Ω at noise temperature of 350K. The voltage output of the load resistor is amplified by an amplifier with a voltage gain of 100 and a noise figure of 2.5 dB.

   The optimum multiplication in any APD decreases as the incident power goes up. Find the value of incident power *in both mW and dBm* (at 1550 nm) that will cause the optimum multiplication factor to have a value of 2.0 for this APD.

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3. A laser operating at 1550 nm is connected to an isolator, a circulator, and a fiber Bragg grating as shown in Fig. 1 on the following page. The power in the fiber at the laser is 1 mW. All splices shown have a loss of 0.5 dB and a return loss of 12 dB. The properties of the isolator are given in Table 1. The port-to-port losses (in dB) of the circulator are given in Table 2 on the following page.

   Using the "dB method", find the value of the power reflected by splice #2 back into the laser *in watts and in dBm*. You may assume that any losses that have not been mentioned are negligible (e.g., the losses in the fibers).

Parameter	Value
Insertion loss	2 dB
Return loss	60 dB
Isolation loss	20 dB

Table 1: Isolator properties for Problem 3.

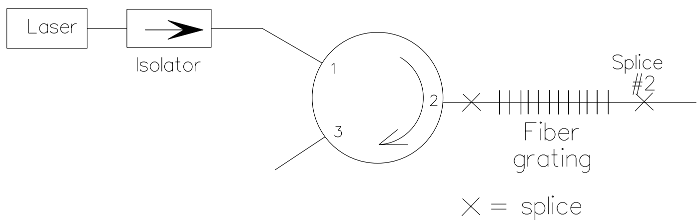

Figure 1: Component connection for Problem 3.

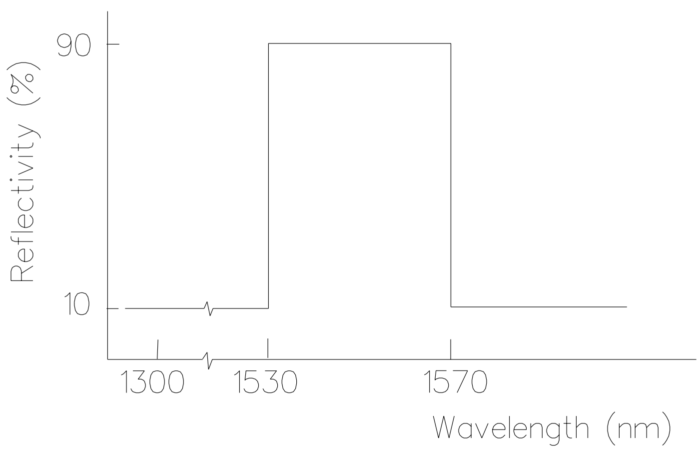

Figure 2: Reflectivity (idealized) vs. wavelength for fiber grating of Problem 3.

	Output		
	1	2	3
1	60	2	30
2	28	60	1.8
3	2.1	32	60

Table 2: Measured dB-loss matrix for optical circulator of Problem 3. The inputs are on the left; the outputs are across the top.