True or False? [2.5*10 = 25]

T or F [0.5 points]. Either way, state the correct explanation/reason. [2 pts].
Right ideas earn partial credit.

- √ Statistical multiplexing is especially useful when the peak rate equals the average rate.
- √ Useful when peak rate is different from average rate
- √ With 8-level signaling (each level = 3 bits), the baud rate =1/4 *bit rate, and the minimum bandwidth required as per Nyquist theorem = 1/6 *bit rate.

Baud rate = 1/3*bit rate

- √ From Amdahl’s law, we learn that the part(s) of the system that is (are) the best candidate for speedup is that which is responsible for a larger fraction of the system’s performance.
- Same as: speed up the common case. The unaffected part will otherwise drag down system performance
Techniques like ASK, PSK, FSK are better than baseband transmission because they use a wider frequency spectrum.

**They use a narrower frequency spectrum**

Dispersion’s primary effect is to dampen signal amplitudes. Dispersion widens signals - causes inter-symbol interference. Attenuation dampens signals.

- All-zeros is a valid set of CRC-bits (i.e., the bits which are finally added to form T(x)), but 0 is not a valid check-digit in the check-digit method.

*You have a “subtract” step in decimal check-digit. The only way to get 0 = 9-9, but 9 can never be the remainder!*  

- On a channel having bandwidth 10 MHz and S/N of 30dB, we can achieve a gigabit (10^9 bits/s) rate.

No. From Shannon’s theorem max = 10 MHz * 10 = 100 Mbps

The reason light does not escape from the sides of a fiber optic cable is because the cable lies underground.

*Due to total internal reflection.*

- The Hamming distance between any two valid codewords in the 1-bit odd parity scheme is 2.

*You need to change at least two bits to maintain parity and get a new codeword.*

- Selective-Reject ARQ makes more efficient use of the sequence number space compared to Go-back-N ARQ.

*Uses only half the sequence number space due to the ambiguity problem.*
1. [10 pts] Derive the Stop-and-wait ARQ utilization formula:

\[ U = \frac{(1-P)}{(1+2a)} \].

Show your work used to get key intermediate results.

\[ W/o \ ARQ: \text{the only useful part is the transmission time} \]

\[ U = \frac{T_f}{(T_f+2T_p)} = \frac{1}{1+2\alpha} \]

\[ W/ \ ARQ, \ U = \frac{1}{N_r(1+2\alpha)}, \text{ .... Eqn (1)} \]

\[ N_r = \text{expected number of cycles to complete transmission} \]

\[ N_r = \sum i P^{i-1}(1-P). \]

Now \( \sum P^i = \frac{1}{1-P} \), and \( \sum i P^{i-1} = \frac{d}{dp} (\sum P^i) = \frac{1}{(1-P)^2} \)

So, \( N_r = \frac{(1-P)}{(1-P)^2} = \frac{1}{1-P} \)

Substituting in Eqn (1), we get:

\[ U = \frac{(1-P)}{(1+2\alpha)} \]

2. [7 pts] Explain why packet-switching is able to exploit temporal multiplexing gains whereas circuit-switching is not. What is the tradeoff packet-switching makes to achieve this benefit?

- In temporal multiplexing, many users may be active at once, but the average over time will be lesser.
- In such a case, users may need to wait for service.
- Circuit switching cannot provide this because all meta-data is associated with timing and will be lost in such a case.
- Packets have explicit meta-data in the form of headers and can hence be “stored” and “forwarded”.
3) (8 pts) Use the (decimal) check digit method to calculate the check-digit for 636. If the number received at destination is 6361, explain why it will be detected as being in error.

- M = 636. Multiply by 10 => 6360
- Divide by 9, remainder = 0.
- Subtract from 9 => check digit = 9
- Number transmitted = T = 6369

When 6361 is received, the receiver divides it by 9 and finds the remainder as 1. But 9 - 1 = 8 which should have been the check digit, whereas it finds that 1 is the check digit. Therefore it flags an error.