(Q.1) \( \frac{C}{N_0} = 4800 \text{ Hz} \)

BER \(< 1 \times 10^{-3} \)

\[ \therefore \text{From the graph; for a BER of } 10^{-3} \text{ the received } E_b \text{ should be at least } 7 \text{ dBs} \approx 5.011 \text{ (factor)} \]

\[ E_b = \frac{C \times T_b}{N_0} \quad \therefore \text{Energy = Power \times Time} \]

\[ \therefore \frac{E_b}{N_0} = \frac{C}{N_0} \times \frac{1}{R_b} \]

\[ \therefore R_b = \frac{C}{(\frac{E_b}{N_0})} \approx 0.960 \text{ kbps} \approx 960 \text{ bps} \]

(\( R_b = 100 \text{ kbps} = 10^5 \text{ bps} \))

\( N_0 = -120 \text{ dBm-Hz} \approx 10^{-15} \text{ (factor)} \)

BER \(< 1 \times 10^{-6} \)

\[ \therefore \text{From graph; for a BER of } 10^{-6} \]

\[ E_b \text{ should be } 10.5 \text{ dBs} \approx 11.22 \text{ (factor)} \]

\[ E_b = \frac{C \times T_b}{N_0} = \frac{C}{N_0} \times \frac{1}{R_b} \]

\[ \therefore C = \left( \frac{E_b}{N_0} \right) \times N_0 \times R_b \]

\[ = (11.22) \times 10^{-15} \times 10^5 = 1.122 \text{ mW} \]

\[ = -59.5 \text{ dBm} \]
(A.3) Now with the data in problem 2, read a) out the value of $\frac{E_b}{N_0}$ instead of the ideal $0^\circ$ rms graph.

$\therefore$ $\frac{E_b}{N_0}$ required is 11.2 dB ≈ 13.18 (factor)

$\therefore$ new $C = (13.18) \times 10^{-15} \times 10^5$

\[ \frac{N_0}{R_b} \]

new $C' = 1.318$ nW = -58.8 dBm

$\therefore$ How much more power required?

\[ = 1.318 \text{ nW} - 1.122 \text{ nW} \]

\[ = 0.196 \text{ nW} \]

*Note please do not subtract powers in dBm.

b) For part 'b' use $\frac{E_b}{N_0} = 10.5$ dB; since $\frac{E_b}{N_0}$ value of $C'$, $N_0$ & $R_b$ is the same as problem 2; hence value of $\frac{E_b}{N_0}$ problem 2.

Now from $\frac{E_b}{N_0}$ use curve of $12^\circ$ rms instead of $0^\circ$ rms to project to find value of BER. You find that value of BER is higher than $1 \times 10^{-6}$. The resolution of the graph is very low; but in my opinion BER is approx. $\approx 5.5 \times 10^{-6}$. 
\( 0.4 \)

\[ N_0 = -140 \text{ dBm-Hz} = 10^{-17} \]

\[ R_b = 10^5 \]

\[ \text{BER} < 1 \times 10^{-6} \]

**Implementation loss** = 1.5 dB

From the 0° rms graph we find that in order to achieve a BER of \( 10^{-6} \); we should have an \( \frac{E_b}{N_0} \)

- However, if a practical working system is built based on this design; then care has to be taken to include worsening of performance due to certain conditions such as increased Electromagnetic interference; solar cycles etc.

- So instead of designing for 10.5 dB; we design for an \( \frac{E_b}{N_0} \) of

\[ 10.5 + 1.5 \text{ dB} = 12 \text{ dB} \]

This 1.5 dB is called **system-margin** or implementation loss.

- Hence in normal conditions BER will be definitely less than \( 10^{-6} \) but in worst-case conditions the received \( \frac{E_b}{N_0} \) will fall from 12 dB to 10.5 dB & ensure that BER is equal to \( 10^{-6} \) or not less.

\[ \therefore \frac{E_b}{N_0} = 12.0 \text{ dB} = 15.84 \text{ (factor)} \]

\[ C' = (15.84) \times 10^{-17} \times 10^6 = 0.1584 \text{ nW} \]

\[ \therefore C = -68 \text{ dBm} \]
0.5) For this problem we need to find a factor $\alpha$

$$\alpha = \frac{1}{T_b} \int_0^{T_b} C_0 \left( \frac{\pi (t - T_b/2)}{T_b} \right) dt$$

$$= \frac{2}{\pi}$$

Energy loss is given by $\alpha^2 = \frac{4}{\pi^2}$

$\therefore$ degradation $\approx -4$ dB

This is the degradation is signal power & not BER.

Loss of signal power found out by $\alpha^2$
#6

Assume the errors can be treated independently of one another.

1) Add the Implementation loss:

\[ BER = 1 \times 10^{-6} \]

* Carrier tracking loop
  VM1 phase error, 120° VM1
  Energy loss: 1.0 dB (\(\sigma^2 = 0.9\))

* Bit Sync
  J_1 + J_2, 5° J
  Implementation loss \(\sim 2.8\) dB

* Use curves handed out in class

**Implementation loss** \(\sim 2.8\) dB