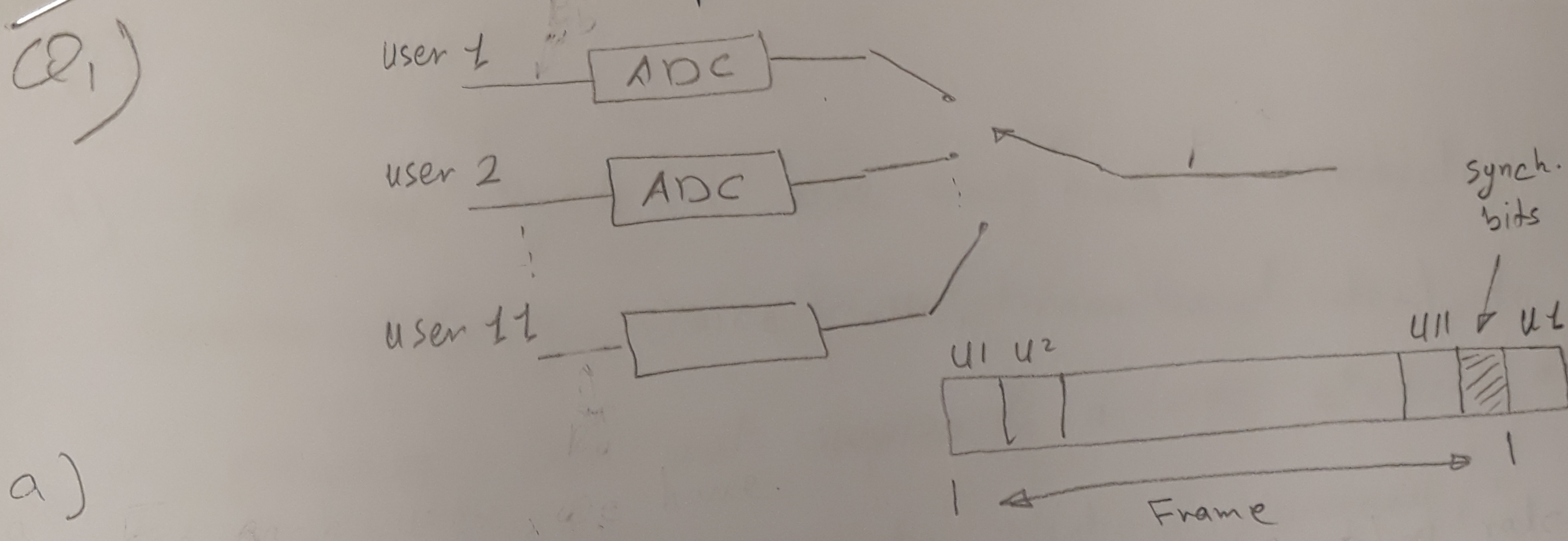
Q1)



a)

$\#$ of bits in a frame $= (11 \times 12) + 2 = 134$ bits

Frame duration $= \dfrac{1}{2 \times 18 \times 10^3} = \dfrac{1}{36000}$ sec

Line speed $= 134 \times 36\,000 = 4.824$ Mbps

b) $BW \geq \dfrac{4{,}824 \times 10^6}{\log_2 M} \Rightarrow M \geq e^{\frac{4.824 \times 10^6}{BW}}$

$M \geq e^{\frac{4{,}824 \times 10^6}{4 \times 10^6}} \Rightarrow M \geq 3{,}3401$

Thus $\boxed{M_{min} = 4}$

* Note that M has to be $M = 2^k$, $k = 1, 2, 3 \ldots$

Q_2)

a) 1G-4G systems are mainly built to provide services (e.g., voice calls, broadband internet, etc) to phones. 5G will support a large variety of use cases such as remote medical surgery, enhanced mobile broadband and autonomous vehicle control

- Wireless cellular networks

  10 kbps

- Wired telephony (PCM)

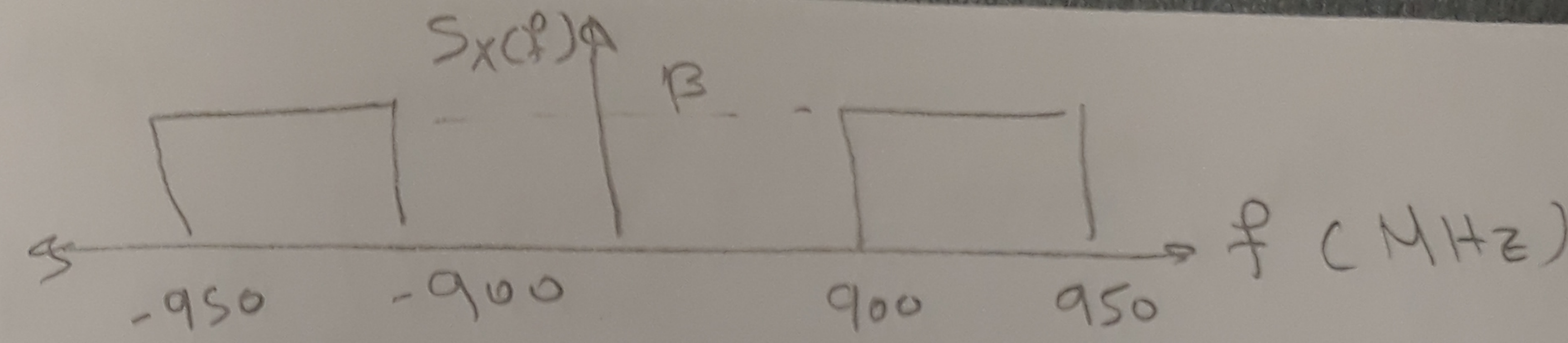
  64 kbps

- Audio CD

- 1.4112 Mbits/sec

b/s

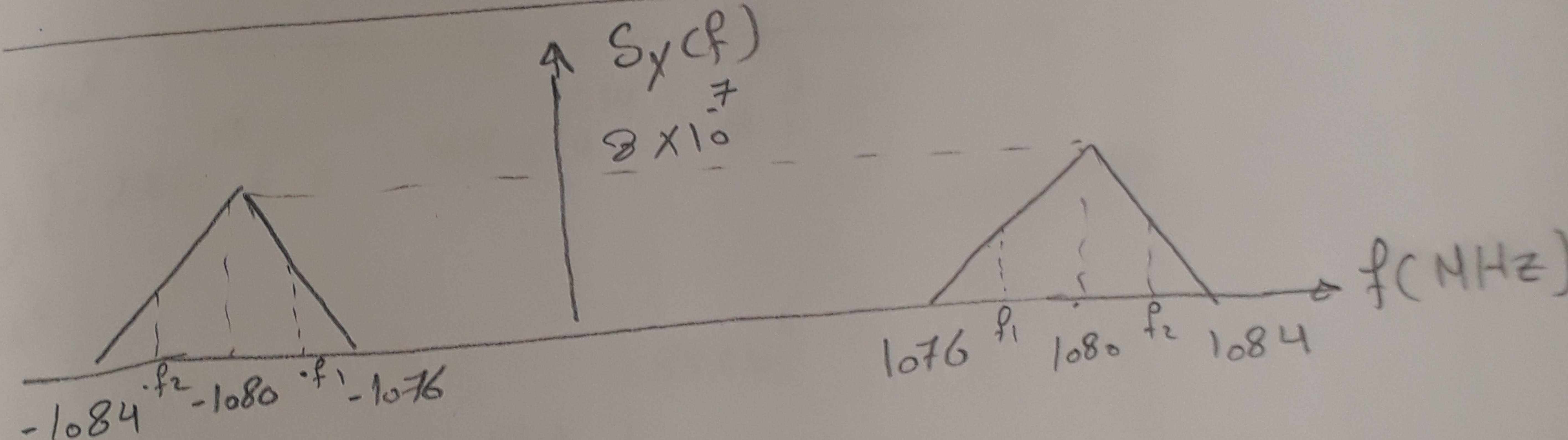
Q3)



- $BW = 950 - 900 = 50\ MHz$
- $P = \int_{-950}^{950} S_X(f)\,df = 2\int_{900\times10^6}^{950\times10^6} B\,df = 2B \times f \Big|_{900\times10^6}^{950\times10^6}$

$= 10^8 B$ watt $= 100B$ (M watt)

Q4)



a) (approach 1)

The power of $Y(t)$ is the area under the two triangles

$P_t = 2 \times \underbrace{\frac{1}{2} \times (1084\times10^6 - 1076\times10^6) \times 8\times10^{-7}}_{\text{area of a triangle}} \Rightarrow \boxed{P = 6.4\ \text{Watt}}$

because we have two triangles

pproach 2 for part (a)

$$P_t = \int_{-1084\times10^6}^{1084\times10^6} S_y(f)\,df = 4\int_{1080\times10^6}^{1084\times10^6} \left[-\frac{8\times10^{-7}}{4\times10^6} f + 2.168\times10^{-4}\right] df$$

$$= 4\times\left[-10^{-13} f^2 + 2.168\times10^{-4} f\right]_{1080\times10^6}^{1084\times10^6}$$

$$\boxed{P = 6.4 \text{ Watt}}$$

b) $$P = 2\int_{1082\times10^6}^{1083\times10^6} \left[-2\times10^{-13} f + 2.168\times10^{-14}\right] df$$

$$= 2\left[-10^{-13} f^2 + 2.168\times10^{-14} f\right]_{1082\times10^6}^{1083\times10^6}$$

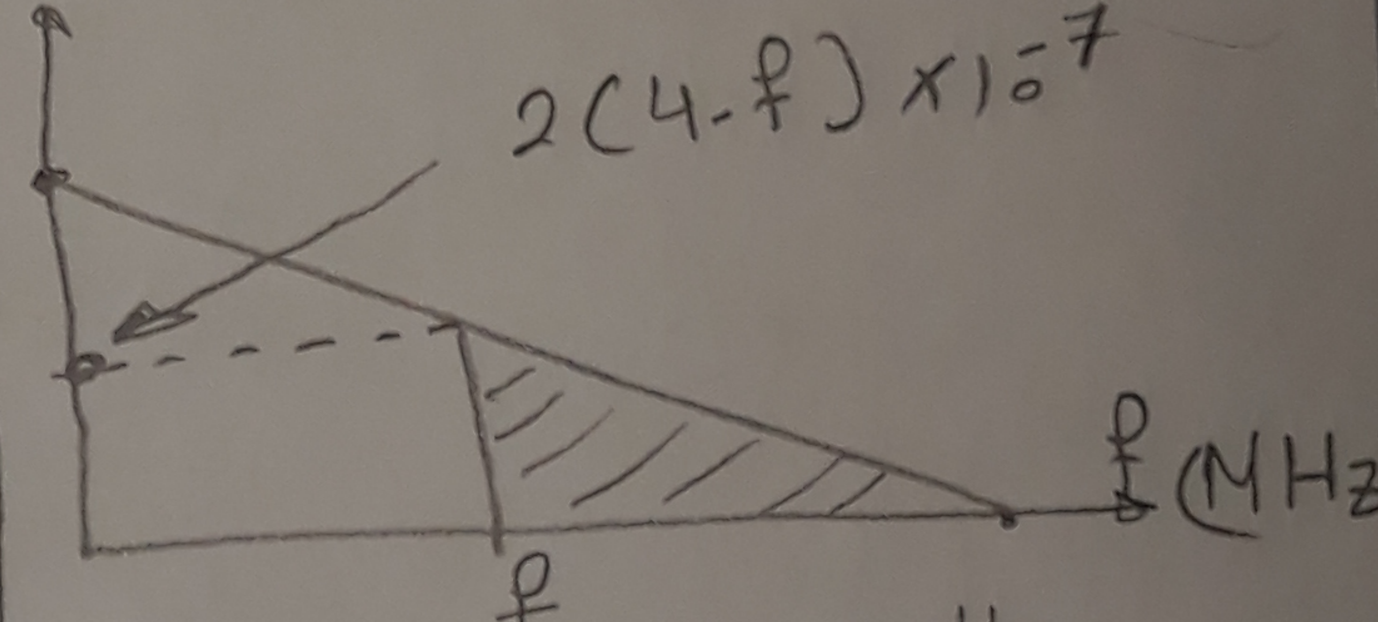
$$= 0.6 \text{ Watt}$$

c) The power at $f = 1083$ MHz $= 0$ since $\int_{-1083}^{+1083} S_y(f)\,df = 0$

d) $BW_{absolute} = (1084 - 1076)\,MHz = 8$ MHz

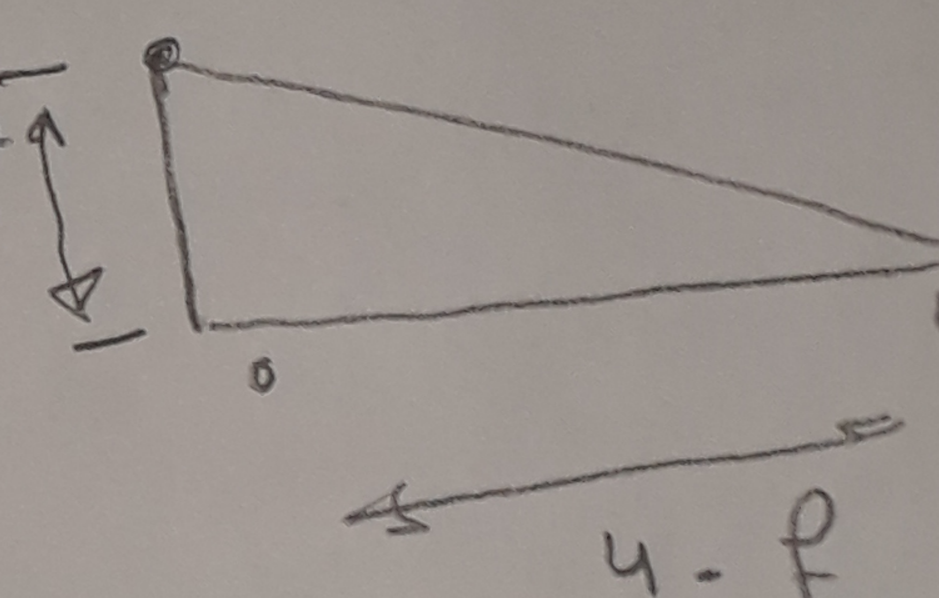
We need to find (f) such that the power in the shaded triangle is $\frac{10}{(4)}$ % of the total power

since we have to consider 4 shaded triangles



Here, we shift the right triangle by 1080

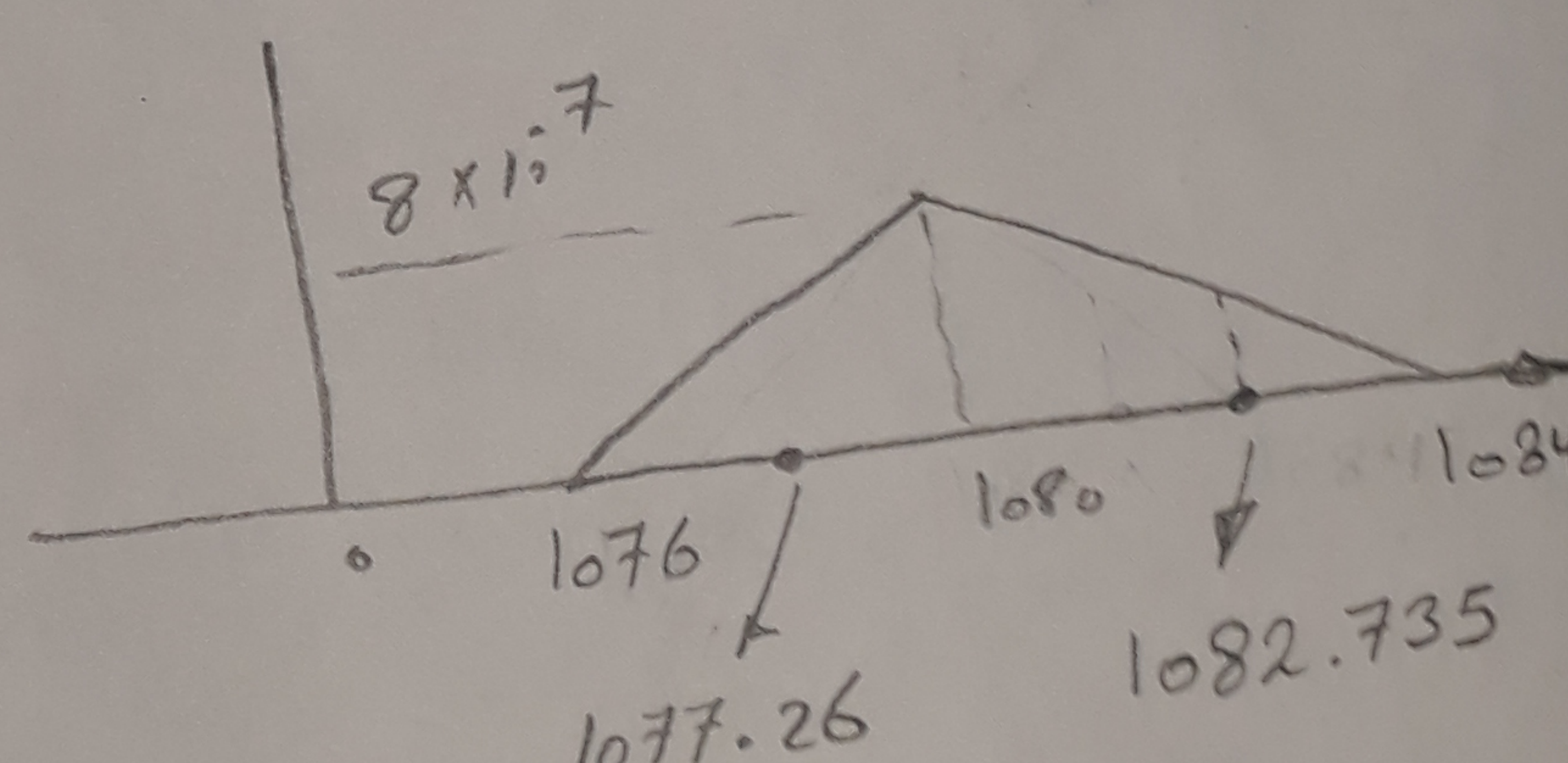
The power in the shaded triangle should satisfy (area of triangle)



$$\frac{1}{2}\times(4-f)\times2(4-f)\times10^{-7}=\frac{0.1}{4}\times6.4$$

$$(4-f)^2=1.6 \Longrightarrow 4-f=\pm\sqrt{1.6}$$

$$f=4-\sqrt{1.6} \Rightarrow f=2.735\ \text{MHz}$$



Thus, the 90% of the power exists between frequencies 1082.735 MHz & 1077.26 MHz

The 90% BW is $2\times2.735=\boxed{5.47}$ #