Name____

Physics 110 Quiz #6 May 26, 2023

Please show all work, thoughts and/or reasoning to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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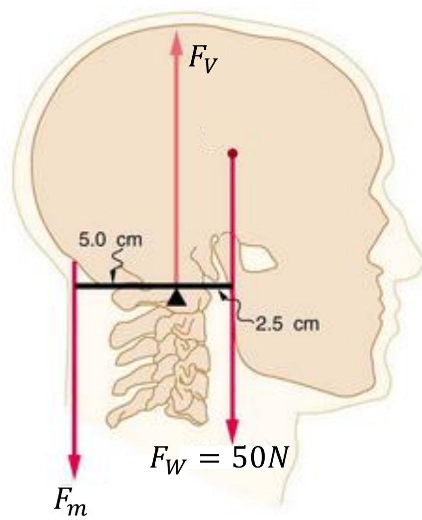
When you're sitting upright, the mass of your head is not located directly over the principal point of support called the atlanto-occipital joint. The muscles at the back of the neck exert a downward force to keep the head upright and facing forward. (As a side note, when these muscles relax, they do not a force, and that's why your head falls forward when you say fall asleep in the class.) (



a. What is the magnitude of the force F_M that the neck muscles need to apply to keep your head upright and looking forward, as shown in the figure on the right?

$$\tau_{net} = \tau_{F_M} - \tau_{F_W} = I\alpha = 0$$
$$\rightarrow \tau_{F_M} = \tau_{F_W} \rightarrow r_M F_M = r_W F_W \rightarrow F_M = \frac{r_W F_W}{r_M} = \frac{0.025m \times 50N}{0.05m} = 25N$$

b. What is the magnitude of the net force exerted on the atlanto-occipital joint F_V?

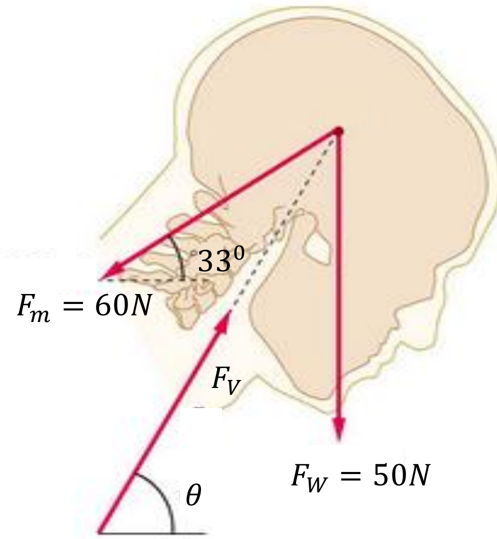
$$F_{net} = F_V - F_M - F_W = ma_y = 0$$
$$F_V = F_M + F_W = 25N + 50N = 75N$$

c. If the elastic modulus of human bone is $E = 3 \times 10^6 \frac{N}{m^2}$, by what amount does the first vertebra of your neck compress due to the weight of your head and the force applied by the neck muscles? Assume that the human vertebra has a diameter $5cm$ and height $8mm$.

$$Stress = E \times Strain \rightarrow \frac{F}{A} = E\frac{\Delta l}{l} \rightarrow \Delta l = \frac{Fl}{AE} = \frac{(F_W + F_M)l}{AE}$$

$$\Delta l = \frac{(25N + 50N) \times 0.008m}{3 \times 10^6 \frac{N}{m^2} \times \pi(0.025m)^2} = 1 \times 10^{-4} m$$

d. Suppose that you put your head forward to read the questions on this quiz as shown in the figure on the right. What is the magnitude of the net force on the atlanto-occipital joint F_V?



x-direction:
$F_{net,x} = +F_V \cos\theta - F_M \cos 33$
$= ma_x = 0$
$F_{V,x} = F_V \cos\theta = F_M \cos 33 = 60N \cos 33 = 50.3N$

y-direction:
$F_{net,y} = F_V \sin\theta - F_M \sin 33 - F_W = ma_y = 0$
$F_{V,y} = F_V \sin\theta = F_M \sin 33 + F_W = 60N \sin 33 + 50N = 82.7N$

$$F_V = \sqrt{F_{V,x}^2 + F_{V,y}^2} = \sqrt{(50.3N)^2 + (82.7N)^2} = 96.8N$$

$$\tan\theta = \frac{F_{V,y}}{F_{V,x}} = \frac{82.7N}{50.3N} \rightarrow \theta = \tan^{-1}\left(\frac{82.7N}{50.3N}\right) = 58.7^0$$

e. At what angle θ does the force exerted on the atlanto-occipital joint occur?

$\theta = 58.7^0$