Ans. to the Q. No-1

Due to time-dilation effect, the time between initial and final ages for the daughters is longer than the four years experienced by her father:

$$t_f - t_i = \gamma(4.000y)$$
$$= 4\gamma \quad \cdots (1)$$

[t_f = Final age of daughter
t_i = Initial age of daughter
γ = Lorentz Factor]

Let,

Initial age of Father = T_i

Final " " " = T_f

$$\therefore T_i = t_i + 20$$

$$T_f = t_f - 20$$

We know, from the question

$$T_f - T_i = 4$$

$$\Rightarrow t_f - 20 - t_i - 20 = 4$$

$$\Rightarrow t_f - t_i = 20 + 20 + 4$$

$$\Rightarrow t_f - t_i = 44 \quad \cdots (11)$$

Put ① in equation ⑪,

$$4Y = 44$$

$$\Rightarrow Y = \frac{44}{4}$$

$$= 11$$

We know that,

$$Y = \frac{1}{\sqrt{1-\beta^2}}$$

$$\Rightarrow \sqrt{1-\beta^2} = \frac{1}{Y}$$

$$\Rightarrow 1-\beta^2 = \frac{1}{Y^2}$$

$$\Rightarrow \beta^2 = 1 - \frac{1}{Y^2}$$

$$\Rightarrow \beta^2 = 1 - \frac{1}{11^2}$$

$$\Rightarrow \beta^2 = \frac{121-1}{121}$$

$$\Rightarrow \beta = \sqrt{\frac{120}{121}}$$

$$= 0.995859$$

Ans. to the Q. No - 2

Given,

Area of the Plates, $A = 7.89 cm^2$

$= 7.89 \times 10^{-4} m^2$

Separation of Plates $d = 4.62$ m.m

$= 4.62 \times 10^{-3} m$

Dielectric constant of material in the ~~top~~ bottom half gap, $K_1 = 11.0$

Dielectric constant of material in the ~~bottom~~ top half gap, $K_2 = 12.0$

permittivity of free space

$\epsilon_0 = 8.85 \times 10^{-12} Fm^{-1}$

∴ Electric field in the bottom half gap,

$$E_1 = \frac{q}{K_1 \epsilon_0 A}$$

∴ Electric field in the top half gap,

$$E_2 = \frac{q}{K_2 \epsilon_0 A}$$

Let;

Thickness of each dielectric $= \frac{d}{2}$

We know,

The Potential difference between the Plates is $V = E_1 \cdot \frac{d}{2} + E_2 \cdot \frac{d}{2}$

$$= (E_1 + E_2)\frac{d}{2}$$

$$= \left(\frac{q}{K_1 \epsilon_0 A} + \frac{q}{K_2 \epsilon_0 A}\right)\frac{d}{2}$$

$$= \left(\frac{qK_2 + qK_1}{K_1 K_2 \epsilon_0 A}\right)\frac{d}{2}$$

$$= \left(\frac{K_1 + K_2}{K_1 K_2 \epsilon_0 A}\right)\frac{qd}{2}$$

$$\therefore \frac{V}{q} = \left(\frac{K_1 + K_2}{K_1 K_2 \epsilon_0 A}\right)\frac{d}{2}$$

We know,

$$C = \frac{q}{V} = \frac{1}{\frac{V}{q}}$$

$$= \frac{1}{\left(\frac{K_1 + K_2}{K_1 K_2 \epsilon_0 A}\right)\frac{d}{2}}$$

$$\therefore C = \frac{2\epsilon_0 A k_1 k_2}{d(k_1 + k_2)}$$

The expression is exactly the same as that for C_{eq} of two capacitors in series, one with dielectric constant k_1 and other with dielectric constant k_2.

$\therefore$ capacitance,

$$C = \frac{2 \times 8.85 \times 10^{-12} \times 7.89 \times 10^{-4} \times 11 \times 12}{4.62 \times 10^{-3} \times (11 + 12)}$$

$$= 1.73 \times 10^{-11} \text{ F}$$

Ans. to the Q. No - 3

Given,

$I = 4\,A$

$d_1 = 6\,m$

$d_2 = 4\,m$

$\mu_0 = 4\pi \times 10^{-7}\ TmA^{-1}$ [we know]

Now, the distance from 'P' point to one wire is,

$$r = \sqrt{\left(\frac{d_1}{2}\right)^2 + d_2^2}$$

$$= \sqrt{\left(\frac{6}{2}\right)^2 + 4^2}$$

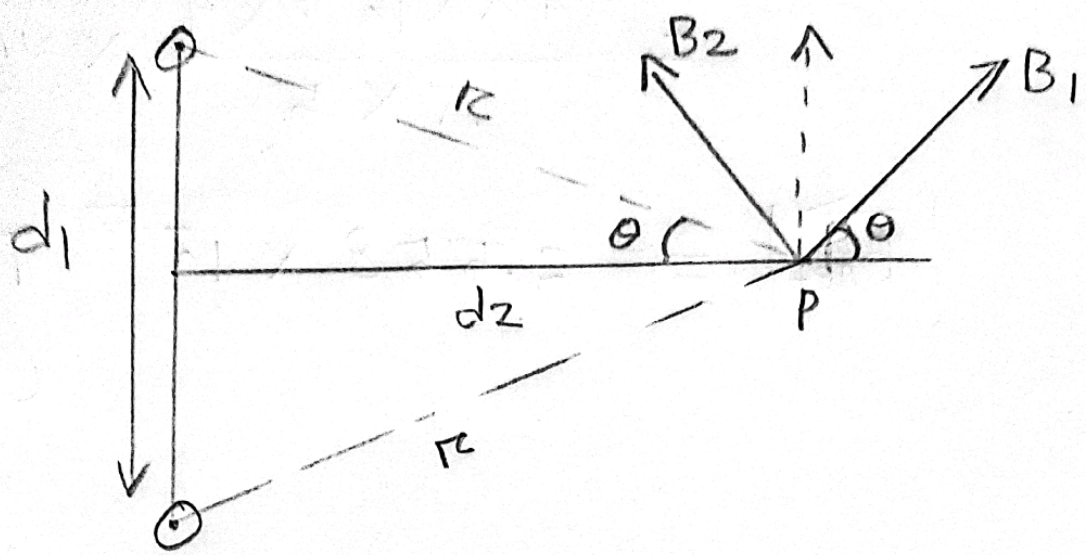
$$= 5\,m$$

Then, the Angle is,

$$\theta = \tan^{-1}\left(\frac{d_2}{d_1/2}\right)$$

$$= \tan^{-1}\left(\frac{4}{6/2}\right)$$

$$= 53.1^\circ$$



Using the right hand rule, we can see that $\vec{B}_{net}$ points along what we will refer to as the y-axis (passing through P), consisting of two equal magnetic field y-component.

We know, Magnatic field,

$$B_{long\ wire} = \frac{\mu_0 i}{2\pi r} \quad \ldots (1)$$

$$|\vec{B}_{net}| = B_1 \sin\theta + B_2 \sin\theta$$

$$= 2 \times B \sin\theta \quad [B_1 = B_2 = B]$$

$$= 2 \times \frac{\mu_0 i}{2\pi r} \times \sin\theta \quad [\text{From } (1)]$$

$$= \frac{\mu_0 i}{\pi r} \sin\theta$$

$$= \frac{4\pi \times 10^{-7} \times 4}{\pi \times 5} \times \sin(53.1^\circ)$$

$$|\vec{B}_{net}| = 2.558 \times 10^{-7} \text{ T (upward)}$$

(Ans.)