2023-Ph-H2-Q2

Section: Our Dynamic Universe
Topic: Forces, Energy and Power

Summary:
An adult with a child is cycling on a straight level path.

- Mass of bike + adult: $85\,\text{kg}$.

- Mass of child + trailer: $28\,\text{kg}$.

- Forward force on bike and trailer: $125\,\text{N}$.

- Frictional force: $45\,\text{N}$ on the bike and $15\,\text{N}$ on the trailer.

Tasks:
(a) Show that the acceleration is $0.58\,\text{m s}^{-2}$.
(b) Determine the tension in the tow bar.
(c) State how the tension changes as speed increases, given acceleration remains $0.58\,\text{m s}^{-2}$.

Solution:

(a) Acceleration:
Total mass:
$$m_{\text{total}} = 85 + 28 = 113\,\text{kg}.$$

Unbalanced force:
$$F_{\text{unbalanced}} = 125 - 45 - 15 = 65\,\text{N}.$$

$$a = \frac{F_{\text{unbalanced}}}{m_{\text{total}}} = \frac{65}{113} \approx 0.58\,\text{m s}^{-2}.$$

(b) Tension in the tow bar:
For the trailer alone:
$$T - 15 = m_{\text{trailer}}\, a,$$

$$T = 28 \times 0.58 + 15 = 31\,\text{N}.$$

Answer: $T \approx 31\,\text{N}.$

(c) Tension change:

- As speed increases, friction on both bike and trailer increases.

- Since the resultant force and acceleration remain constant, the driving force must increase to balance friction.

- Thus, **tension in the tow bar increases.**

Guidance for Students:

- Identify unbalanced force: forward force minus all resistive forces.

- Use $F = ma$ for the whole system first, then for individual parts.

- Remember, tension is the pulling force within the tow bar.

Revision Tips:

- $F_{\text{unbalanced}} = F_{\text{forward}} - F_{\text{friction}}.$

- Acceleration is the same for bike and trailer since they're connected.

- Always check if forces are **in series** or act **in parallel** on different parts.