

Force, mass, acceleration, free body diagrams



A child pulls some toy trains which are connected together with magnets.

The trains have a mass of 50g each, and the maximum tension force between the magnetic couplings before they separate is 1.5N.

The frictional force between each train and the track is 0.1N.

Assume the track is level.

Draw diagrams where necessary.

1. The child pulls one train so that it accelerates at 0.1ms^{-2} .
 - a. What force did the child pull with?

2. The child then attaches another train behind the first, and pulls the first train so that they accelerate at 0.1ms^{-2} .
 - a. What is the total frictional force on 2 trains?

 - b. What force did the child pull with?

 - c. What was the tension in the magnetic coupling?

3. The child then attaches another train behind the others and pulls the front train so they all accelerate at 0.1ms^{-2} .
 - a. What force did the child pull with?

- b. What was the tension in the magnetic couplings between...
 - i. the front train and second train

- ii. the second train and third train

- 4. The child keeps adding more trains, and always pulls the front train so that they accelerate at 0.1ms^{-2} .
 - a. How many trains is it possible to pull before a coupling breaks?

- b. Which coupling will break?

- c. What could the child change so that more trains can be accelerated at 0.1ms^{-2} without any couplings breaking? Suggest some different ideas.

- 5. (Optional): I made up the mass of each train, the maximum tension force between the couplings, and the frictional force for each train. How could you determine these things experimentally if I gave you a load of trains? You can write your ideas on another piece of paper.