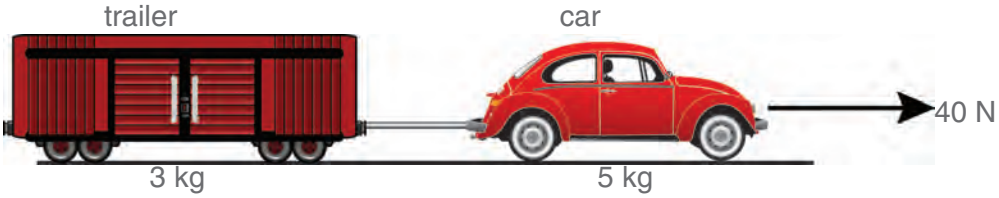
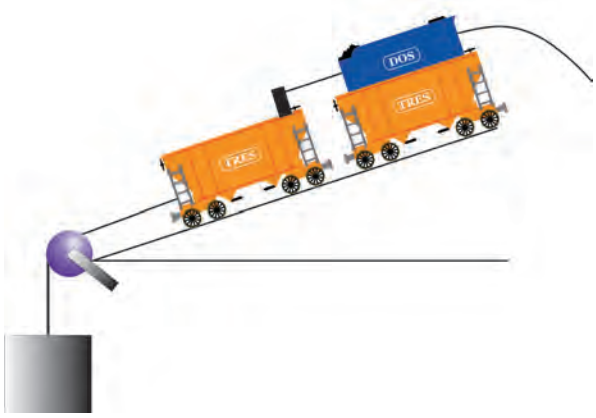
Contextual questions

1 A toy trailer, mass 3 kg, is connected to a toy car, mass 5 kg, with a light, solid rod.
Initially, the system is at rest on a horizontal surface.
When a horizontal force, magnitude 40 N, is applied to the car, the entire system accelerates in a straight line to the right.
Whilst in motion, frictional forces of 3 N and 5 N act on the trailer and car respectively.



1.1 State Newton's second law of motion in words.
1.2 Draw a labelled force diagram for each toy.
1.3 Apply Newton's second law to the toys and calculate:
i the acceleration of the system; and
ii the force that the rod applies on the trailer.

2 The overloading of vehicles is one of the greatest problems on SA roads. A few learners investigated the relationship that force, mass, acceleration, stopping distance and stopping time of a moving vehicle has on one another.
One group of learners did the following investigation:



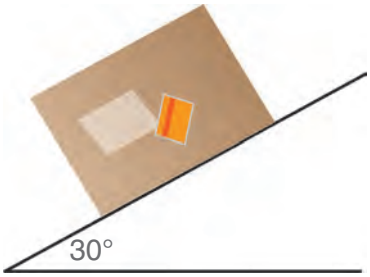
Apparatus used:
- Four trolleys
- A ticker timer
- Four lengths of ticker tape
- A trolley track
- An inelastic string
- A pulley
- A 250 g weight piece

The trolley track was inclined slightly to compensate for friction.
The weight caused the trolley to accelerate down the slope.
The incline was kept constant during this experiment.
The mass was increased after each experiment by stacking an extra trolley on top of the ones used previously. After analysing the four ticker tapes, the following results were recorded:

Force (N)	Mass (trolley units)	Acceleration ($m \cdot s^{-2}$)	$\frac{1}{\text{mass}}$ (kg^{-1})
2,5	1	4,4	
2,5	2	2,8	
2,5	3	2,3	
2,5	4	1,9	

2.1 Formulate a hypothesis for this experiment.
2.2 Complete the fourth column of the table.
2.3 Draw a graph using the last two columns of the table.
Use a line that fits best for the graphs.
2.4 Draw a conclusion from the graph.
2.5 Extrapolate (extend) the graph. Give a possible reason why the best fitting line does not go through the origin.
2.6 Use your conclusion in Question 2.4 to explain to motorists why it is dangerous to overload vehicles.
2.7 Calculate the velocity of the first trolley after moving 10 m from rest.

3 Frictional forces are often annoying, but without these forces it would be impossible to walk.
3.1 Use Newton's third law to explain how friction helps us to move forward. You can draw a sketch to aid your explanation.
3.2 Picture yourself standing with your school bag, on the ice in the middle of a frozen dam. The ice is completely frictionless, therefore you cannot run, walk or even crawl and it is too hard to dig into the ice to get a grip. Use the principles of physics to explain in detail how you can get off the dam without outside help.
3.3 An object is at rest on an inclined plane as indicated in the diagram. It is just at the point of moving.
Complete a force diagram and label the forces as follows:



F_N: normal force
F_g: weight
f: frictional force
$F_{||}$: component of weight ll to the surface
$F_{\perp}$: component of weight $\perp$ to surface

3.4 Calculate the coefficient of static friction of the system.

4 Kgosi and Nkidi want to investigate Newton's second law of motion. They place a trolley (mass 1 kg) on the trolley track and lift the end of the track slightly, until the trolley moves at a constant velocity.

Investigation 1:

- For the first part of the investigation they use four identical weights.
- Kgosi fastens one weight to the trolley using a light string and leads the weight with the string over the pulley as indicated in the diagram.
- He places the other three weights on the trolley.
- He releases the trolley and the ticker timer makes dots on the ticker tape that is attached to the trolley.
- Nkidi uses the ticker dots to calculate the acceleration of the trolley.