11-14 Force and Acceleration

Prerequisites

Students should have already completed the **Force & Motion** and the **Acceleration** sheets

The Main Points

- If there are balanced forces (no resultant force), motion doesn't change. Velocity (speed and direction) stays the same, and there is no acceleration.
- If there is a resultant force (unbalanced forces), motion does change - there is a velocity change and therefore an acceleration.
- The acceleration depends on the ratio of the resultant force to the mass
- We use a system of units where the acceleration in m/s^2 equals the ratio of the resultant force to mass (in N/kg).
    - Acceleration = Resultant Force / Mass
    - In symbols: F = ma where F is resultant force, m is mass and a is acceleration
- Remember that in F = ma, F is the resultant force, not the size of any one particular force

Teacher Quarter Briefing

- Introduction: https://youtu.be/PmTH41rTBqE
- Practice: https://isaacphysics.org/gameboards#teach_quart_forceacc
- Review: https://youtu.be/Vs0pe2Pze6I
- If you want to go further: https://isaacphysics.org/pages/covid19_gcse_archive#13
- If you want to see a different approach to teaching the links between force and motion, you can study momentum https://isaacphysics.org/pages/covid19_gcse_archive#19

Class Question Notes

The worksheet can be printed either in full, or in cloze text form (where the red text is missing, and students can complete these blank spaces after class discussion). The online version of the notes requires the appropriate text to be dragged to the right place in the sentences.

1. The aim of this question is to show students where the idea of a = F/m comes from. Please do use this as a discussion point. In a race, would the trolley or the skateboard be quickest off the line? The trolley has a bigger force, but more resistance. Even though the trolley has the biggest resultant force (once resistance has been taken care of), it is 'bigger' and therefore the 150N of resultant force has less effect than the mere 16N on the 2kg skateboard.
2. Here we write the answers to Q1(b) but with m/s^2 as the unit.
3. Here students write word equations. Please do ensure that they put 'Resultant force' not just 'force' in (a) and (c) - the distinction is vital when we come to the later questions (eg Q6).
4. Here students write symbolic equations.
5. These question practise the use of F=ma or the idea of sharing resultant force over the mass.
6. This is the first question where there are two forces. First we calculate the resultant force (4 - 1.6 = 2.4N) then put this into a = F/m to work out the acceleration 2.4/1.6 = $1.5m/s^2$.
7. These questions are done in the same way as Q6, however the student is not guided to work out the resultant force first.
8. This is like Q6, but now they work out the resultant force from F=ma = 24N. They then add this to the downwards force of 9N to find out the propulsion required (33N). Note that this works out as the resultant force must be 33N - 9N = 24N as calculated in the first part of this question.
9. In this question, the student uses the equation for acceleration (velocity change / time taken) from the Acceleration sheet to work out a = 100/80 = 1.25m/s2. This requires a resultant force of F =

ma = 300 000 x 1.25 = 375 000N, and if there is 50 000N of friction, then the engine needs to provide a force of 375 000N + 50 000N.

Homework Question Notes

These questions have a very similar form to the questions in the class task, so students can refer back to their earlier answers to help

1. This question asks students to put the notes of the Class sheet in their own words (if using the paper version) or select the best descriptions (if working online).
2. This is a rerun of Q1 on the class sheet, working out which of two bags will accelerate more rapidly when pushed (kicked, most likely). Not that you will permit bags to be kicked in your school, of course.
3. In this question, the resultant force per kilo (from Q2(b)) is put in units of acceleration m/s^2.
4. Here students complete the word equations. Do encourage them to write ‘resultant force’ and not just ‘force’ when they answer (a).
5. Here students write the symbolic equation, and can refer to this when doing later questions.
6. This is equivalent to class Q5 - where there is only one force on each object, and students use F = ma to work out the missing variable.
7. This is equivalent to class Q6 - there are two forces. The student first works out the resultant force (6N), then uses a = F/m to work out the acceleration (6N/2.4kg = $2.5m/s^2$).
8. Students naturally assume that heavy objects fall faster than lighter ones (or if we wish to use better terminology, heavy objects will have a greater acceleration when dropped). This is not true when the objects are heavy enough and slow enough that we can ignore drag. This question gets students to work out why. In short, if acceleration depends on resultant force per kilo. An object with twice the mass has twice the weight (remember W = mg), so it will have the same force per kilo, and therefore the same acceleration. In this question the student first calculate the weight of an apple (1N) and a bag of flour (20N), then uses a=F/m to work out the acceleration for each object.
9. This question is more of a challenge as it involves drag.
    a. Empty lunchbox 0.1kg x 10N/kg = 1N; filled box 1.6kg x 10N/kg = 16N
       The filled box has a total mass of 0.1 + 1.5 = 1.6 kg
    b. Resultant forces: empty box 1N - 0.2N = 0.8N; full box 16N - 0.2N = 15.8N
    c. Acceleration (a=F/m): empty box 0.8/0.1 = $8m/s^2$; full box 15.8/1.6 = $9.9m/s^2$ (2sf)
       Isaac allows a range of options on rounding here, students do not have to give their answer to two significant figures.
    d. The heavy box hits the ground first (as they would expect) but not by much. The drag has a bigger effect on the lighter box (its ‘force per kilo’ is greater).

Extension questions from ‘Step Up to GCSE Physics’:
https://isaacphysics.org/gameboards#step_up_phys_11_b1
https://isaacphysics.org/gameboards#step_up_phys_12_b1

Extension questions from ‘Step Up to GCSE Physics’ using Momentum:
https://isaacphysics.org/gameboards#step_up_phys_13_b1
https://isaacphysics.org/gameboards#step_up_phys_14_b1
https://isaacphysics.org/gameboards#step_up_phys_15_b1