11-14 Force and Motion

Prerequisites:

Students should have already completed the **Forces** and the **Weight** sheets

The Main Points

The summary points are given at the top of the front and back side of the class work sheet.

- Balanced forces (2N upwards and also 2N downwards) cancel out as far as the object's motion is concerned. (They might stretch the object, but we don't worry about that here.)
  - Where there are more than two forces, we add up the total forces to the left, and compare the total force to the right. If these are equal, we have balanced forces.
  - If the forces are balanced, and cancel out, we say that there is **zero resultant force** (nothing left over).
  - A stationary object stays still if the forces are balanced.
  - A moving object carries on moving at a steady speed in a straight line if the forces are balanced. To give an example, if when cycling, you pedal with a force exactly equal to the friction and drag, your bike carries on at the same speed. If your driving force is bigger than the friction & drag (even if only a bit), the cycle will speed up.
- If the forces are not balanced, we calculate the resultant force (the force left over once we have cancelled out as much as we can).
  - If the total force pulling to the right is 5N, and the total force pulling to the left is 4N, the resultant force is 5N - 4N = 1N to the right.
  - Some students might actually find it easier to add the forces using negative numbers for the forces pointing one way, and positive numbers for forces pointing the other way. The sign (+ or -) of the final total gives the direction of the resultant force.
  - An unbalanced force in the direction of motion causes an object to speed up
  - An unbalanced force opposing motion slows the object down. If you are cycling and stop pedalling, the driving force has stopped, but the friction and drag still point backwards. This backwards force slows the bike down, but does not stop it instantly.
  - An unbalanced force to the side turns an object.

The most likely sticking point

- The students will find this point hard: if a ball is moving upwards, there must have been an upwards force on it at some stage, **but there might not be an upwards force on it now**.
- **It takes a net (or resultant) force to start something moving, but does not take a force to keep something moving**. This is very counterintuitive for students as we live in a world where there are always forces resisting motion, and so as soon as you take the driving force away, things slow down. However, the driving force needed for a bus to go at 30mph is exactly equal to the resistance force (to cancel it out) - you don't need any surplus. If you do give extra force, the bus gets faster.
- Some students find it helpful if you point out that when you turn the engine off, a vehicle does stop, but it doesn't stop immediately. So in that time while it is slowing down, it is definitely moving forward without a forward force on it. Others find it helpful if you ask students to picture a vehicle where there was a on/off key for the friction as well as for the engine, and ask them what would happen if you set the engine to keep the vehicle at a steady speed, and then turn the engine off and leave the friction on (slow down), next friction off with engine on (speed up), and finally both off.
- Students will accordingly struggle with the last part of class Q4 and homework Q8b: after a ball has been thrown upwards and let go, there is no upwards force on it at all (apart from a little upthrust due to buoyancy which we neglect here), and yet still it rises (albeing while slowing down)!

Teacher Quarter Briefing

- Introduction: https://youtu.be/Ev8dhWZcbUU
- Practice: https://isaacphysics.org/gameboards#itsp_teach_forcemot
- Review: https://youtu.be/IBA7YH3eYe0
- If you want to go deeper, please see the 'Force and Acceleration' materials

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.

Shallow learning gradient online assignment - q1,2,4,5,6,8
Steeper learning gradient online assignment - q1,2,3,4,5,6,7,8,9

1. In this question, students decide for each diagram whether the forces are balanced or not.
2. Here students calculate the resultant force (and say 'zero' if the forces are balanced). To give an example, for (g) total force to the right is 7N, force to the left is 5N, so resultant is 2N to the right.
3. Here students add one force to each example in Q1 to make the forces balance. For 2(g) they would add 2N to the left to cancel out the resultant force worked out in Q1(g).
4. Students add a 3mN upwards force and a 1mN left force to balance the forces given.
5. Students draw the direction of the extra force needed to speed up a falling penguin or slow it down.
6. In this question, students match up a description of what a force does with the direction it points.
7. Here students apply the notes at the top of the sheet and choose whether the object will speed up, slow down, stay still, go at a steady speed or turn. This is a more detailed version of q6. In (c) the gravity force is at right angles to the motion and causes the planet to turn (change direction) so it can keep moving on its circular orbit. The force does not speed up or slow the planet down. Planets in elliptical orbits do speed up (slow down) when they get nearer to (further from) the star. In (g) point out that although the ball is going upwards, the resultant force is downwards. There is no upwards force on the ball simply because it is moving that way. There was once an upwards force to make it move upwards (from the person), but once the person let go, that force stopped acting.
8. The aim here is for students to draw the driving force as larger than drag when speeding up, and smaller when slowing down. Bonus mark for the student who shows the two forces equal in strength for the steady speed situation.
9. Here we have a downwards weight force and upwards drag on a leaf falling from a tree. In (b) the drag is less than weight, so the leaf gets faster, but in (c) forces are balanced and the leaf falls at a steady speed (later, students will learn this is called **terminal velocity**).

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

Shallow learning gradient online assignment - q1,2,3,6,7,8,10
Steeper learning gradient online assignment - q2,3,4,5,6,7,9,10,11,12

1. This question is similar to class Q1 - students determine whether the forces are balanced or not.
2. This question requires descriptions of balanced, unbalanced and resultant forces.
3. Here students work through something similar to class Q2 calculating resultant forces.
4. Here students put an extra force on each block to balance the resultant calculated in Q2.
5. Here students explain how they worked out the resultant force.
6. This is similar to class Q4, but the upwards force now needs to be 4mN to leave a resultant force of 1mN upwards as requested.
7. Students draw the direction of the force needed to speed up a fish or change its direction of motion.
8. As in class Q6, students match a description of a force to the direction it points.

9. This question is about resultant forces on a bungee jumper
    a. Bungee just goes taught: large weight downwards, some drag & tension upwards
    b. Bottom of motion: same weight downwards, no drag (there is no motion to resist), larger tension upwards
    c. Bungee goes slack on way up: same weight, some drag downwards, no tension.
10. This question requires students to use the notes at the top of the back page of the class sheet.
11. This is similar to class Q7 - students choose whether each thing will speed up, slow down etc. It is a more detailed version of Q9.
12. Here a student labels contact, weight and drag forces on a basketball thrown upwards
    a. Being thrown: large contact force upwards, weight downwards, small drag downwards
    b. After letting go: no contact, weight still downwards, small drag downwards
    c. At top of motion: no contact, weight still downwards, no drag (no motion to resist)

    The weight should be the same in all three pictures. Remember: just because something is going upwards does not mean that there is currently an upwards force on it.