11-14 Forces

The Main Points

- Forces push, pull, stretch, squash, hold or bend the things they touch.
- Forces can cause things to
    - Change speed (speed up - think of engines OR slow down - think of friction in brakes)
    - Change direction (think of the force from tyres needed to turn a corner)
    - Change shape (think of moulding with clay)
    - Change length (forces make springs longer and shorter)
- Forces can also be used to cancel out the effect of other forces - in particular the use of engines to prevent friction slowing vehicles down, and support forces to stop things falling.
- Some forces have special names
    - **Weight** = downwards force of gravity
    - **Friction** = contact force acting along a surface (preventing it slipping or sliding)
    - **Normal reaction** = contact (support) force acting perpendicular to a surface
    - **Driving force** = the KS3 term for anything done by an engine. Sometimes this is also referred to as thrust, although technically 'thrust' should only be used for direct propulsion (e.g. propeller, jet engine, rocket) rather than anything which uses motors and wheels (where we do actually rely on friction to grip the ground to move the car forward).
    - **Upthrust** = the buoyant force of anything submerged in a fluid (including air - think of helium balloons)
    - **Drag** (air or water resistance) = force acting against motion in a liquid or gas.
    - **Lift** = upwards force made by wings when they are pushed through air.
- We draw **force diagrams** to show the forces acting on objects. Force diagrams
    - Do not need to be artistic or even realistic (labels in rectangles are fine)
    - Force arrows should start at the point where the force acts, and point in the direction of the force. Force arrows point away from objects, not towards them (for 'push' and 'pull').
    - We use longer arrows to represent stronger forces.
    - Where there are two objects touching in real life, it may help if the diagram shows a gap between them to make it clear which forces are affecting which object.
- **Contact** forces only work if something is touching.
    - Examples include drag, friction, normal reaction, lift, upthrust. Drag, lift and upthrust only work if the fluid (e.g. water/air) is touching the object.
- **Non-contact** forces work even if objects are not touching. These include
    - **Weight** = the force on gravity
    - **Electrical forces** (a rubbed comb can bend the flow of water from a tap even if the comb is not touching the water)
    - **Magnetic forces** (magnets do not need to touch in order to repel or attract).

What we are not covering at this stage

Please note that as this is an introductory lesson, we do not cover the following two ideas, but students might ask about them.

- **Newton's Third Law**. Students in this sheet will only be asked to draw the forces on a single object. Once students are drawing forces on a pair of objects which touch or attract/repel, then they will learn that these forces come in pairs. If a Magnet is pulling a Paper Clip to the right, the Paper Clip is also pulling the Magnet to the left with an equal magnetic force. This is called Newton's Third Law. If this were not true, then when the Magnet & Paper Clip were thought of as a single object, the two forces would not cancel, and the force left over could accelerate the joint object. That sounds fun, but doesn't happen.

- **The link between force and motion**. This is subtle and very hard to understand for the first time - even Galileo took decades to work it out. In this sheet we explain that forces are needed to speed things up, slow things down or change their direction. We also explain that we need an engine to keep something moving at a steady speed if there is something like friction which would otherwise slow it down. However what we don't say just yet is that ***forces aren't needed to maintain motion*** (when there isn't resistance), nor do we say that ***just because something is moving upwards doesn't mean that there is an upwards force on it*** (think of a ball thrown upwards just after you let go of it). We leave that until later when the student is ready for it because they have a better understanding of resultant force and acceleration from other lessons. We cover this point extensively in our Force & Motion and Force & Acceleration sheets later.

Teacher Quarter Briefing

- Introduction: https://youtu.be/YKxIDoVIf38
- Practice: https://isaacphysics.org/gameboards#itsp_teach_force
- Review: https://youtu.be/hgbeGYjplN8

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

1. Here, students choose whether the statements are always true, sometimes true or false. For example 'You can feel forces' is sometimes true' (you can feel it if someone pushes you, but you can't feel your own weight). 'When you catch a fast ball, you feel a force as it stops' is always true. 'You can see forces' is false. Often you can see the effects of forces (a tree swaying in the wind), but this does not mean you can see the force itself.
2. In this question, students match up observations to explanations involving forces. For example 'A ship floats' is linked to 'Water pushes it upwards.'
3. The online questions are multiple choice, where students are guided with prompts. The question is 'Do you need a force?' and the answers include 'Yes, because we are speeding it up or slowing it down' and 'Yes, because we are changing its shape' and so on. The options given can be thought of as a checklist when finding out if a force is acting.
4. This is similar to question 3 but without the prompts - students have to apply the checklist themselves to work out if there is a force.
5. Here, in the online version, students drag and drop the right answer into the right place in the table. You will probably want to project the online version while students are doing this table in class, especially if students are unfamiliar with the words.
6. Here students need to criticise the diagram. In the online version, a list of possible errors is given, and students have to tick one of the problems. Students are not expected to label the forces on the supporting shelf. Please encourage students to draw a gap between the box and the shelf, and to ensure all arrows (whether push or pull) point away from the box. Students then draw a diagram to fix the errors. In the online version, the student clicks when ready to be shown a better diagram.
7. As an introduction to drawing their own diagrams, students have to label the forces on diagrams they have been given (they write words next to the arrows). In the online version, the labels can be dragged to match with the arrows. Remember that the name of the upwards force varies depending on what is causing it. If it is being supported by a surface, then it is a **normal reaction**. If there is a 'floating' force, then this is **upthrust**, while wings (and rotors) cause **lift**.

8. In this question, students have to put the arrows on and label them. Note that the supermarket trolley is being pushed (so there are horizontal forces), but that the helicopter is hovering (so no horizontal forces).
9. In this question, the students identify the contact and non contact forces. On the online version, they tick the contact forces. Feedback is given if they tick any of the wrong ones.

Homework Question Notes

The homework questions mirror the classwork questions, so students can refer back to the work done in class to help them answer the questions. In question 10 (where they draw their own diagrams), they are not given the answer until they have provided information about the forces involved. The online version assumes that the basketball is being thrown horizontally, so the pushing (normal reaction) force is to the right.

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