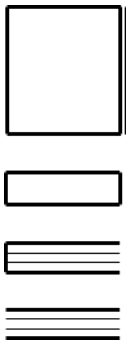
Magnetism Prep Lab: 3D spatial reasoning and the cross product

Lab report format: Redraw ALL figures on the provided template, You can print draw and scan or you can edit the PDF. One report per person.

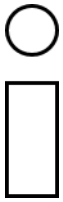
PART 1: Perspective views of a table-top coordinate system

View icons

Here are a set of simplified diagrams for representing some common objects when viewed from different perspectives. The figures can also be rotated by 90 or 180 degrees.



book



water bottle

pencil

arrow

Book: i) from above, binder on left side ii) view from binder side iii) binder side on left iv) binder side occluded "behind"

Bottle: i) from above, or below ii) from any side view

Pencil and arrow: i) from any side view ii) pointing towards viewer iii) pointing away from viewer

Exercise 1.1

Figure 1 depicts two pencils and a water bottle on a table, viewed from above. On a separate sheet, redraw the figure from the perspective of points A,B,C and D. The view from "D" has already been drawn in Figure 2, as an example.

Fig. 1

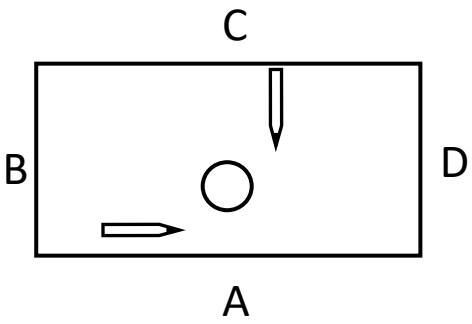
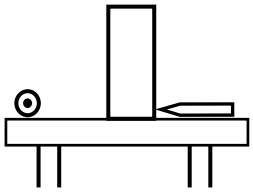


Fig. 2 : view from "D"



Repeat for the following two figures. (A book and a water bottle; two pencils). In Fig. 4, do not draw a pencil if it is occluded by the other one.

Fig.3

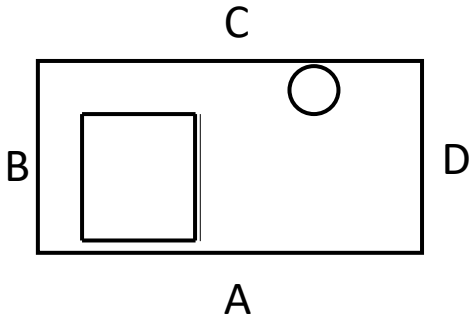
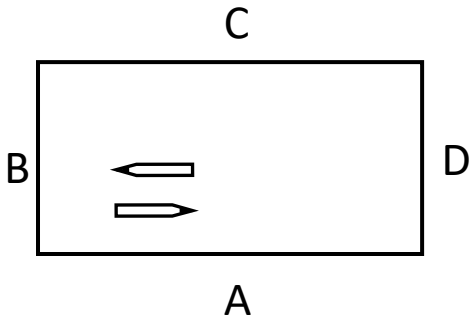


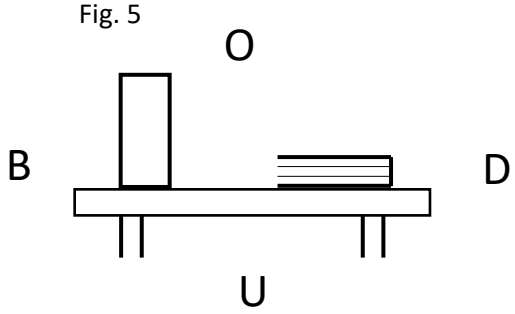
Fig. 4



Exercise 1.2

The following figure represents a water bottle and a book on a table, viewed from side "A". The bottle is touching edge "A", and the book is touching side "C". Redraw the figure from the four perspectives indicated, starting with view "O". Views "O" and "U" are "view from **O**verhead" (looking down[1]) and "view from **U**nder" (looking up[2]), respectively.

Fig. 5



Exercise 1.3

Redraw the following figures from the perspectives indicated. Draw occluded pencils using dotted lines. Figures 7 and 9 depict 3 arrows. In Fig. 9, the "z" arrow is located directly above the A-B corner of the table. Show the x-y-z labels for each perspective of Fig. 9.

Fig. 6 (three pencils)

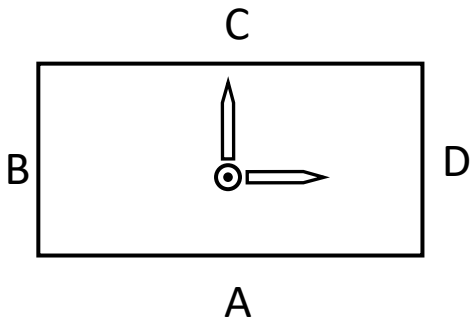
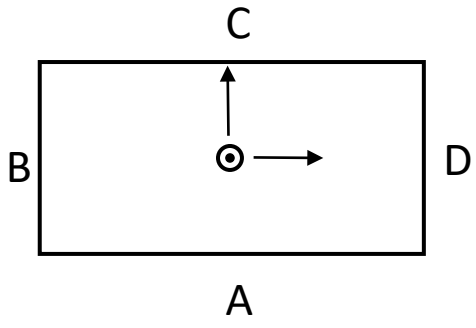


Fig. 7 (three arrows)



[1] Oriented with the top of the head at « C », left shoulder towards « B ».
[2] Oriented with the top of the head at « A », left shoulder towards « B ».

Fig. 8 (4 pencils)

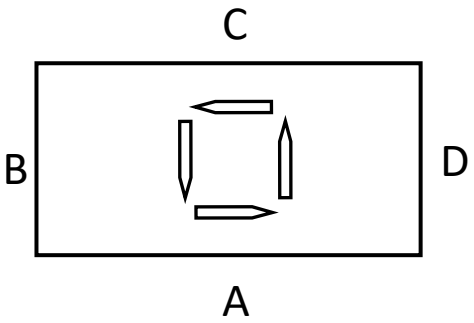
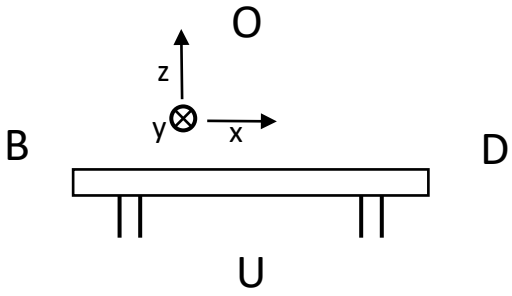


Fig. 9 (3 arrows, labelled x, y and z)



PART 2: Perspective views of a smartphone coordinate system

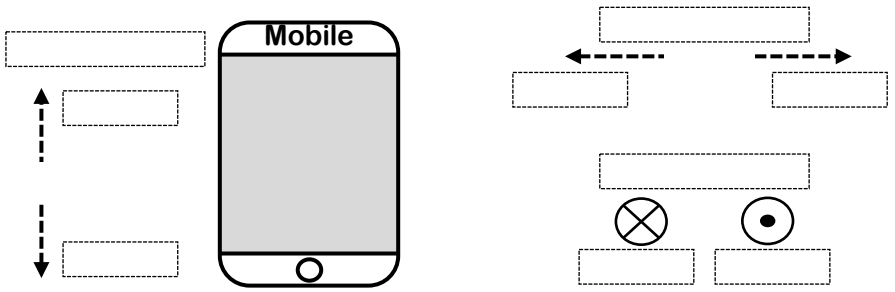
Principle: *A non-moving accelerometer always produces a vector pointing upwards, away from the earth. An accelerometer app displays three accelerometer signals, one for each axis. The non-zero signal corresponds to the axis that is currently aligned with the terrestrial "earth-sky" axis. Its sign tells you whether it is the positive or negative side of that smartphone axis that is currently aligned with the terrestial "up" direction.*

Exercise 2.1

1. Read the appendix "Smartphone vocabulary".

2. Download and install the accelerometer app according to the "AppInstructions" document for your OS. (Only the first 3 steps are needed).

3. Start the app. Hold your smartphone in different orientations and observe the signals produced. Determine the convention for its internal coordinate system by applying the principle "Immobile accelerometers always report which way is up". Examine enough orientations so as to observe both positive and negative values individually on each of the three axes. Not all phones share the same coordinate system choice! Labels: "x-axis","y-axis","z-axis","positive","negative".

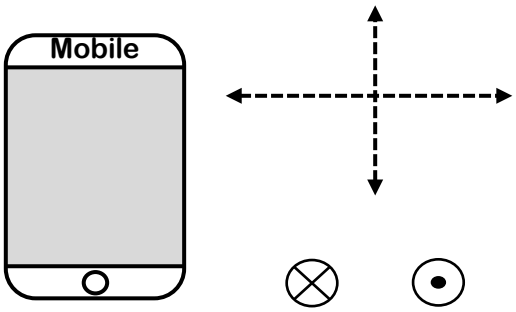


Manufacturer and model of your phone: _____

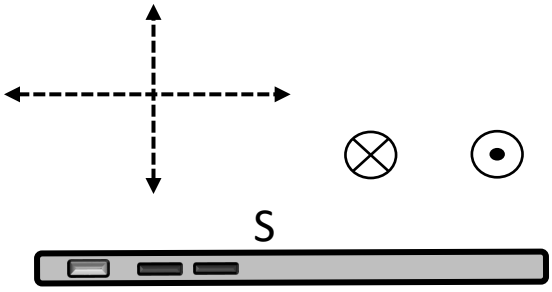
Exercise 2.2

For each of the following views, 6 directions are indicated. Apply the appropriate label among the choices “+x”, “-x”, “+y”, “-y”, “+z” or “-z”.

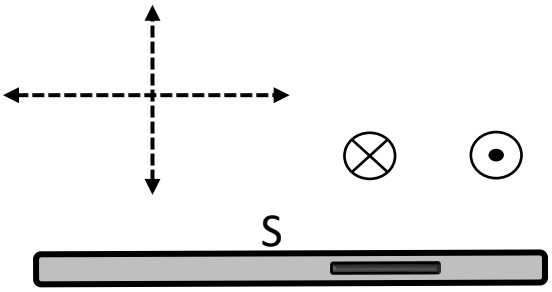
1. A view from the smartphone’s “selfie” side, looking in the “camera” direction.



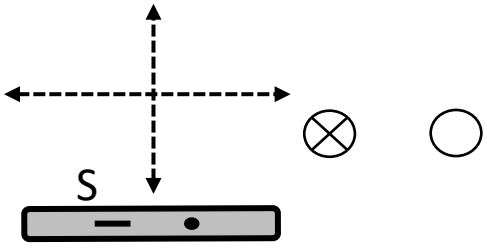
2. A view from the phone’s left side, looking in the rightwards direction. (In this and subsequent figures, “S” indicates the screen side.)



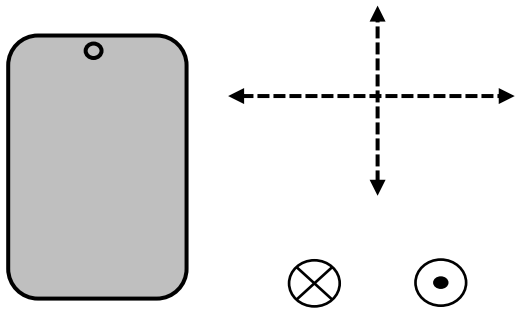
3. A view from the phone’s right side, looking in the leftwards direction.



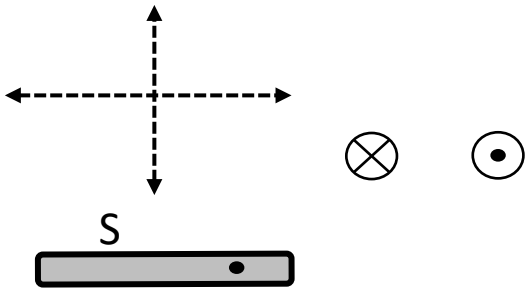
4. A view from the phone’s “mouth” side, looking in the “earwards” direction.



5. A view from the phone's "camera" side, looking in the "selfie" direction.

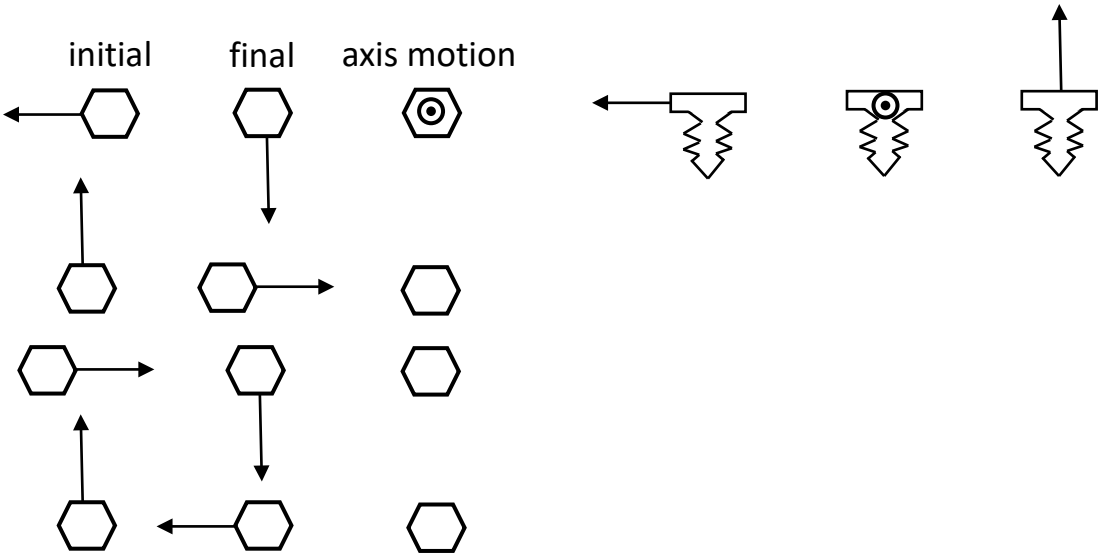


6. A view from the phone's "ear" side, looking in the "mouthwards" direction.



PART 3: Depicting the right-hand rule using screws

A wrench (arrow) is connected to a screw (hexagon) and rotated a quarter-turn from an initial to a final orientation. Use the right-hand rule to determine the axial motion of the screw. On the right are side views of the same screw. For each row, fill in the "axis motion" using the appropriate direction symbol and re-draw the whole sequence from the side view. The first row is completed as an example.


initial
final
axis motion

Appendix: Vocabulary for the external geometry of a smartphone

The external geometry of a cell phone is roughly that of a box. A box has 6 walls and three axes. When you view your screen in portrait mode, you see a rectangle. We name the two axes of this rectangle the *left-right axis* and the *long axis*. The third axis is the one that runs perpendicular to the screen, which we will call the *camera axis*. You can imagine this last axis as a line going from your eyeballs to the screen surface and through the phone to the back surface.

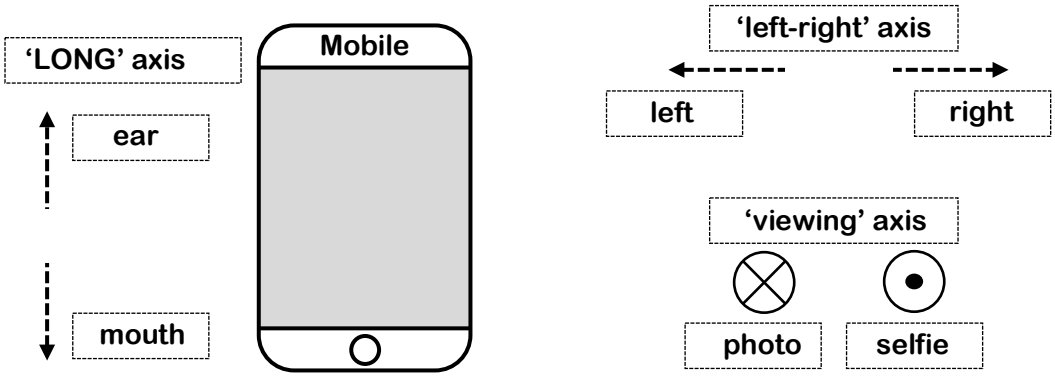
To avoid confusion, we refer to the six walls as follows[3] :

LEFT-RIGHT axis
directions : left, right

LONG axis
directions : « mouth », « ear »

CAMERA axis
directions : « selfie », « photo »

Making 3-D drawings all the time is tedious, so physicists usually stick to "flat" drawings, and use "dot-or-cross" circles to indicate directions that are "out" or "in" perpendicular to the drawing:



Your phone does not use this vocabulary, however. It uses only « x » « y » and « z » for the axis names and positive or negative values to indicate directions. Which axis does « y » refer to? Which direction is positive? The answers depend on how the coordinate system of your phone has been configured by the manufacturer.

[3] Notice how we have carefully avoided the use of the words "up" and "down", words which become confusing once you start changing the orientation of your phone.