Apparent Weight in Elevator

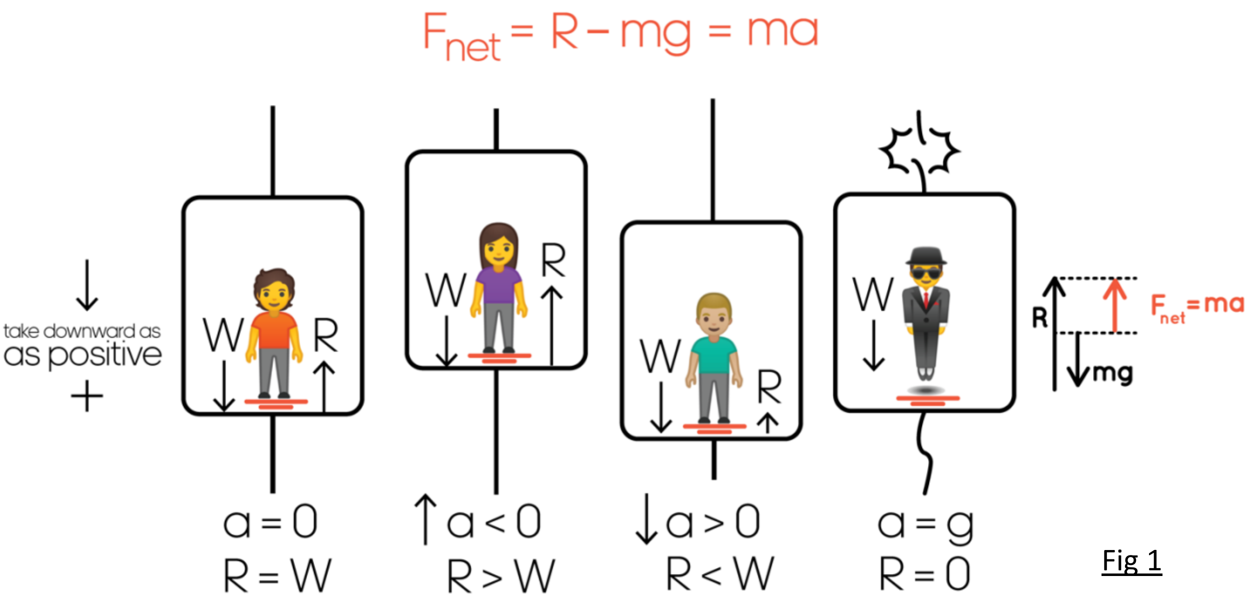


Fig 1

Purpose

To use the "AP-Sensor" app to investigate the acceleration and deceleration during a trip and its effects on the apparent weight of an object in elevator.

Theory

- In the study of Physics, the **mass** of an object *m* is absolute and universal in the physical world. The unit is kilogram (kg).
- The **weight** of an object *W*, the terms that we generally use in daily life, actually refers to the downward **force** acting on the object of mass *m* by the gravity.
- By Newton's Second Law, F = ma, where *a* refers to acceleration. Given that *g* is the acceleration due to gravity, the weight of an object is therefore W = mg. The unit will be Newton (N). The acceleration due to gravity on Earth is assumed to be $9.81ms^{-2}$ in DSE level.
- In daily life, we use balance to measure "mass" instead of "weight". If you are 50kg in mass, that means your weight should be 50kg times $9.81ms^{-2}$, equals 490.5N! The acceleration due to gravity on Moon is about $1.63ms^{-2}$. Your weight on Moon is 50kg times $1.63ms^{-2}$, equals 81.5N!
- The **apparent weight** of an object measured by a balance is the **normal reaction** acted on the object. Occasionally, the apparent weight may vary when an object experiences external force that acts along the line of gravity. In this experiment, for instance, we stay in an elevator that moves upward or downward. This will change the apparent weight of all

objects inside the elevator.

- In the free-body diagram above (Fig 1), *R* is the upward normal reaction acting on the object by the elevator, the downward force *mg* is the absolute weight of the object, F_{net} is the **net force** acting on the object which is equal to *ma*, where *a* is the net acceleration of the object. Therefore, $F_{net} = R - mg = ma$, taking upward as positive. (You can take downward as positive. It will give you the same result in opposite sign.)
- When the elevator is at rest or in uniform motion, $a = 0$, $F_{net} = 0$, $R = mg$, i.e. the normal reaction equals to the weight, which makes sense. When the elevator accelerate upward (positive a), the apparent weight becomes $R = m(g + a) > mg$, i.e. heavier than normal. When the elevator accelerate downward (negative a), the apparent weight becomes $R = m(g - |a|) < mg$, i.e. lighter than normal. ($|a|$ = absolute value/magnitude of a)

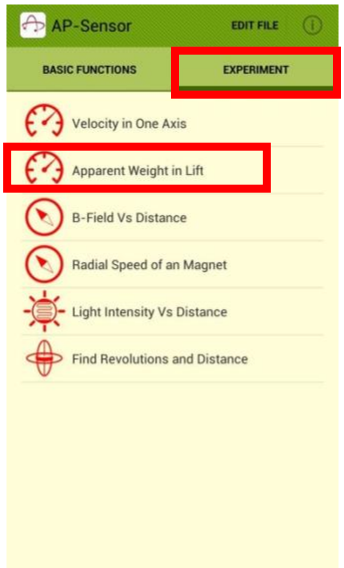
Apparatus

- Mobile device with "AP-Sensor" app
- An elevator
- A balance

Procedure:

<u>Start the app</u>

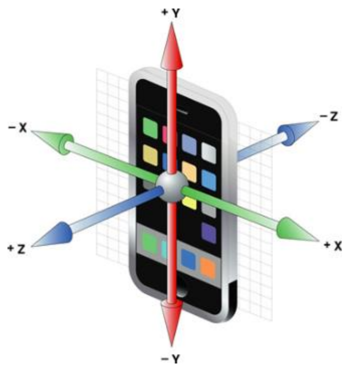
1. Run the app "AP-Sensor". In the "Experiment" tab, press "Apparent Weight in Lift" to start this experiment (Fig 2). An alert message regarding the sign of motion will show up. Press "OK" to proceed.



<u>Fig 2</u>

<u>Choose axis and calibrate for the experiment</u>

2. Press the "Axis Selection" tab on the left of the instantaneous Acceleration reading (up to 4 decimal places) to choose a desired axis (Fig 3). In this case, z-axis is chosen and the display of the device should face to the top (Fig 4).
   Note: The axes may vary in different devices. You are advised to test the axes of your device in advance.



<u>Fig 3</u>

3. In the elevator, keep the phone steady and press "Calib". Wait 5 seconds for the calibration (Fig 5). The error will be shown in the area. If you find the error not sensible, you can press "Reset" and press "Calib" to calibrate again.

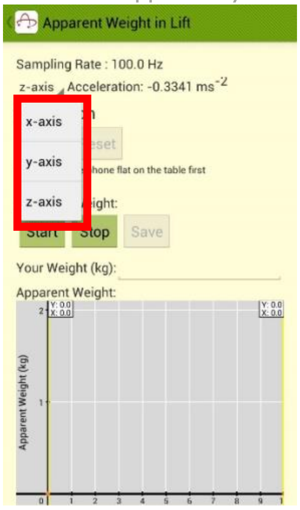


Fig 4

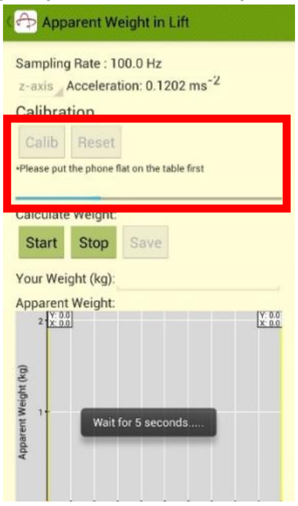


Fig 5

Fig 6

Start experiment

4. Before the elevator moves, measure your normal weight with the balance and enter it in the “Your Weight (kg)” field (Fig 6).

5. When the elevator is ready to move, put the device on the floor and press “Start” button to start recording. Observe the change of apparent weight shown in the balance. Press “Stop” to end recording after the elevator comes to complete stop. Apparent weight and acceleration over time will be recorded and plotted in the graphs below.

6. You can use the “Zoom” and “Cursor” functions to view the data on the graphs (Fig 7). Note that the graph could only shows data within the recent 50 seconds, but all data will be recorded when you save the activity.

7. Press “Save” button to save data. You can save data into .csv format, or press “Plot” to preview data in graph.

8. Repeat the experiment with elevator going in opposite direction. Investigate and explain the apparent weight change in different statuses, and find the acceleration and deceleration of the elevator.

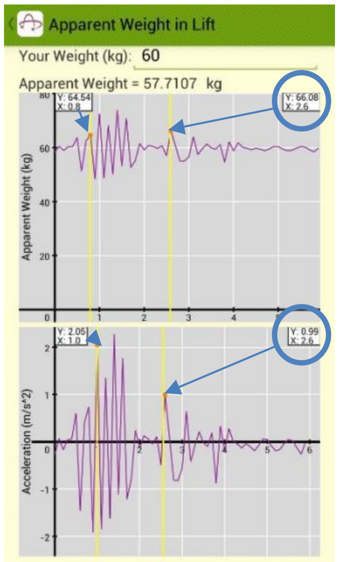


Fig 7

Data

Record the data in the following tables and make analysis.

<u>Traveling Upward</u>

Status	Acceleration (ms^{-2})	Theoretical Apparent Weight (kg) = m(g+a)	Observed Apparent Weight on Balance (kg)
Accelerating			
Constant Speed			
Decelerating			

<u>Traveling Downward</u>

Status	Acceleration (ms^{-2})	Theoretical Apparent Weight (kg) = m(g+a)	Observed Apparent Weight on Balance (kg)
Accelerating			
Constant Speed			
Decelerating			

Discussion

1. Describe the acceleration of the elevator, and the apparent weight over time in the experiment.
2. Justify any difference between the theoretical apparent weight and the observed apparent weight on balance.
3. From the acceleration-time graph, how long does the elevator take to accelerate and decelerate? Hence, can you estimate the traveling velocity of the elevator at its uniform motion? Also, can you estimate the distance traveled by the elevator in due course? Does the value match the height of floors that the elevator traveled?
4. If the acceleration-time graph does not appear to be at regular acceleration when the elevator accelerates/decelerates, what are the possible reasons?
5. What will happen to the acceleration and apparent weight if the elevator is free-falling?