LESSON PLAN / Riding the Lift: Forces in Motion
Phone Sensor + Simulation Investigation | Newton's Second Law in an Accelerating Lift

Subject / Level	H2 Physics | JC1
Topic	Dynamics - Newton's Laws of Motion
Duration	2 x 50-minute periods (Period 1: sensor + simulation activity; Period 2: analysis + debrief)
Class size	Up to 32 students in groups of 4
Venue	Physics lab / classroom with student smartphones and internet access
Prior knowledge required	Newton's First and Second Laws, free body diagrams, normal contact force, acceleration sign convention
Simulation link / QR code	https://iwant2study.org/lookangejss/02_newtonianmechanics_3dynamics/ai/ElevatorSim/elevator_phone_accelerometer_sim.html
Prepared by	________________________________
Date	________________________________

A Learning Outcomes

By the end of this investigation, students should be able to:

- Apply F_net = ma to analyse forces on a person in an accelerating lift, using N = m(g + a).

- Use a smartphone accelerometer through a browser-based simulation to connect sensor readings with acceleration direction.

- Use simulation data to predict how a weighing scale reading changes during each phase of lift motion.

- Distinguish clearly between velocity direction and acceleration direction when deciding whether N > W, N = W, or N < W.

- Draw proportional free body diagrams for a person in an accelerating, constant-speed, and decelerating lift.

- Evaluate limitations of phone-sensor data and simulation models, and suggest practical improvements.

B Curriculum Alignment (MOE H2 Physics Syllabus 9749)

Content reference	Section 3: Dynamics - Newton's laws of motion; free body diagrams; mass and weight
Skills assessed	Analysis, evaluation, communication, modelling, interpreting sensor/simulation data
21CC links	Critical and inventive thinking; collaborative learning; confident use of technology
Assessment mode	Formative: group handout, teacher questioning, exit ticket

C Resources & Pre-lesson Preparation

Per group of 4 students	Teacher preparation
- 1 smartphone with motion sensor access - 1 second device or laptop to view / record the simulation if available - Browser-based accelerometer simulation - Group handout - Calculator - Pen / pencil	- Test the simulation on Android and iOS before class - Check whether browser motion permission is required - Prepare a QR code or short URL to the simulation - Prepare fallback slider-mode data for students without working sensors - Prepare one worked example using a = +0.40 m s^-2 and m = 60 kg - Decide whether students use g = 10 N kg^-1 or 9.81 N kg^-1

Logistics Note
Modern phone browsers may block motion sensors unless the page is served through HTTPS and the user grants permission. If a student phone cannot detect the accelerometer, the simulation's slider mode is still usable: students can drag the pivot/slider to create a model acceleration and complete the same Newton's Second Law reasoning.

D Lesson Timeline

PERIOD 1 (50 min) - Phone Sensor + Simulation Exploration

Time	Phase	Teacher Actions	Student Activity / Look-fors
0-5 min	Set-up & Roles	Distribute handout. Assign roles: Sensor Operator, Simulation Operator, Calculator, Recorder. Project QR code / link.	Students open the simulation and check whether sensor permission appears.
5-12 min	Theory Hook	Ask: "A lift starts upward. Does the scale reading change because the lift is moving upward, or because it is accelerating?" Take responses without immediately resolving all misconceptions.	Students predict N > W, N = W, or N < W for a lift starting upward and approaching the top floor.
12-20 min	Simulation Briefing	Demonstrate: phone held still, small tilt, small horizontal motion, fallback slider. Point out displayed accX, accY, accZ and the pendulum / force response.	Sensor Operator practises gentle movements. Recorder notes how the simulation responds.
20-38 min	Data Collection	Groups complete Part C. Prompt: "Which reading changes when you tilt? Which reading changes during a brief acceleration?" Reinforce safety: no running, throwing, or large swings.	Groups collect qualitative sensor observations and sketch the response of the simulation.
38-47 min	Elevator Model Build	Give or project the standard lift acceleration sequence: +0.40, 0, -0.40, 0, -0.40, 0, +0.40 m s^-2. Ask groups to predict scale readings before calculating.	Groups fill the phase table and decide N > W, N = W, or N < W for each phase.
47-50 min	Checkpoint	Collect one completed row per group or ask groups to photograph their Part D table.	Students identify one phase where velocity and acceleration point in opposite directions.

PERIOD 2 (50 min) - Force Analysis + Debrief

Time	Phase	Teacher Actions	Student Activity / Look-fors
0-10 min	Calculation Warm-up	Write N = m(g + a) on the board. Work one example: m = 60 kg, a = +0.40 m s^-2.	Students complete expected N and scale-reading rows for all phases.
10-22 min	Simulation vs Model	Ask groups to explain where phone-sensor data is useful and where the idealised elevator model is cleaner.	Students compare noisy/qualitative phone readings with the clean acceleration profile.
22-35 min	FBD Practice	Direct groups to draw free body diagrams for accelerating upward, constant velocity, and decelerating upward. Check arrow lengths and labels.	Groups draw N and W arrows with correct relative lengths.
35-44 min	Whole-class Debrief	Cold-call groups for Q7-Q9. Emphasise: the scale measures normal contact force, not mass; acceleration direction determines the scale reading.	Students self-correct in a different colour.
44-50 min	Exit Ticket	Pose: "A lift is moving downward but slowing down before the ground floor. Is N > W, N = W, or N < W? Draw the FBD."	Expected: acceleration upward, so N > W.

E Model Answers & Common Misconceptions

Question / Focus	Model Answer / Key Points	Common Misconceptions to Address
Sensor calibration	When the phone is held still, the sensor mostly reads the support force needed to hold the phone at rest relative to Earth. Small tilts redistribute components between axes.	Students may think a non-zero reading means the phone is moving. Clarify that accelerometers measure proper acceleration, including support effects.

Question / Focus	Model Answer / Key Points	Common Misconceptions to Address
Acceleration vs velocity	Scale reading depends on acceleration direction, not velocity direction. A lift moving upward but slowing has downward acceleration, so $N < W$.	Students often say "going up means heavier" and "going down means lighter."
$N = m(g + a)$	Taking upward as positive: $N - mg = ma$, hence $N = m(g + a)$. If $a > 0$, $N > W$; if $a = 0$, $N = W$; if $a < 0$, $N < W$.	Students may treat mass and weight as interchangeable or forget that a can be negative.
Simulation limitation	The simulation gives a clean model and sensor response, but real lift data includes vibration, phone orientation errors, permission issues, and sampling limits.	Students may assume simulation output is automatically "true" without checking assumptions.

F Differentiation Strategies

Support	Core	Extension
Provide the acceleration sign for each phase. Give a partially completed table and one worked calculation.	Complete all tables, calculations, FBDs, and explanation questions independently.	Derive $a = N/m - g$ from the scale reading, compare using $g = 9.81$ N kg^{-1}, and discuss jerk/comfort in lift design.

G Formative Assessment Opportunities

Timing	Assessment Strategy	What to look for
P1 opener	Prediction: scale reading when lift starts upward	Whether students use acceleration, not velocity, in reasoning
P1 activity	Check Part C sensor observation table	Phone orientation, gentle handling, useful observations rather than random numbers
P2 mid	Monitor FBD sketches	Correct directions, labels, and proportional arrow lengths
P2 debrief	Cold-call explanation of decelerating upward phase	$N < W$ because acceleration is downward
P2 exit	Lift moving downward but slowing down	Acceleration upward; $N > W$

H Safety & Contingency Planning

Safety Considerations	Contingency: Sensor or Browser Unavailable
- Students must remain seated or standing still while using the phone sensor. - Use only gentle tilts and short, small hand motions. No running, throwing, shaking near faces, or lift-lobby crowding. - Do not require students to enter a real lift for this version unless teacher supervision and school approval are arranged. - Phones should be held securely with two hands when collecting sensor observations.	- Use the simulation's slider mode to model acceleration. - Project the teacher's working phone and let groups analyse the displayed values. - Use the provided idealised acceleration sequence for all calculations. - If the simulation does not load, complete the activity as a paper modelling exercise using the phase table.

Key Equations for Reference
$F_{net} = ma$ | $N - mg = ma \Rightarrow N = m(g + a)$ | Scale reading in kg = N / g | $g = 10$ N kg^{-1}

Simulation link

Open the live elevator phone accelerometer simulation: Open simulation webpage

https://iwant2study.org/lookangejss/02_newtonianmechanics_3dynamics/ai/ElevatorSim/elevator_phone_accelerometer_sim.html

This link is placed here so the handout, lesson plan, or answer key still points students and teachers back to the correct simulation when downloaded or shared.