# Riding the Lift: Forces in Motion

Phyphox Group Investigation | JC1 H2 Physics | Dynamics

| Role | Member Name | Role | Member Name |
|---|---|---|---|
| Phyphox Operator | ____________________ | Camera Operator | ____________________ |
| Scale Person | ____________________ | Recorder | ____________________ |

## A Quick Theory

Two forces act on you in a stationary lift: weight W = mg (downward) and normal contact force N (upward, what the scale measures). When the lift accelerates, applying Newton's Second Law (upward positive) gives:

$$N - mg = ma \quad \Rightarrow \quad N = m(g + a)$$

| Lift motion | Acceleration a | Scale reads… |
|---|---|---|
| Accelerating upward / decelerating downward | $a > 0$ (upward) | More than actual weight |
| Constant velocity or stationary | $a = 0$ | Actual weight |
| Decelerating upward / accelerating downward | $a < 0$ (downward) | Less than actual weight |

## B Equipment & Procedure

### Phyphox Setup

- Smartphone with Phyphox app
- Open: Movement → Elevator
- Hold phone still & upright throughout

### Scale & Camera Setup

- Digital weighing scale (flat on lift floor)
- Second phone: slow-motion video (240 fps)
- Camera aimed at scale display throughout

### Steps

1. **Setup:** Count off "3, 2, 1" — start Phyphox recording and slow-motion video simultaneously.
2. **In the lift:** Scale Person stands on the scale. Do not hold the handrail.
3. **Journey:** Press Level 12. Remain still. When doors close at L12, press Level 1.
4. **Stop:** Stop both recordings when the lift is fully stationary at Level 1.
5. **After:** Export Phyphox data as CSV. Review slow-motion footage as a group.

> ⚠ **Safety**
> Do not rush for the lift. Stay still. Be considerate to other building users.

## C Phyphox Graph Analysis

Using your Altitude, Velocity, and Acceleration graphs, complete the table and answer the questions below as a group.

| Phase | Time range (s) | Direction of a | v: increasing / constant / decreasing |
|---|---|---|---|
| L1 → L12: lift starts moving upward | | | |
| L1 → L12: constant speed upward | | | |
| L1 → L12: decelerates at L12 | | | |
| Stationary at L12 | | | |
| L12 → L1: lift starts moving downward | | | |
| L12 → L1: constant speed downward | | | |
| L12 → L1: decelerates at L1 | | | |

### Group Discussion Questions

Q1. What does the flat plateau on the altitude graph represent? How long did the lift stay at Level 12?

Q2. From the velocity graph, estimate the lift's maximum speed in m $s^{-1}$. Show how you read this off the graph.

Q3. The accelerometer data looks noisy compared to the altitude data. Why might this be?

Q4. At which two phases do you expect the scale to read below the person's actual weight? Explain using $N = m(g + a)$.

## D Weighing Scale & Slow-Motion Data

Review your slow-motion footage frame by frame. Match each phase to the Phyphox timestamp. Record the scale reading for each phase.

Mass of Scale Person: _________ kg    Weight $W = mg$ = _________ N

| Phase | Scale reading (kg) | N = reading × 9.81 (N) | Expected: N > W, N = W, or N < W? | Matches theory? Y / N |
|---|---|---|---|---|
| Stationary at L1 | | | | |
| Accelerating upward | | | | |
| Constant speed upward | | | | |
| Decelerating at L12 | | | | |
| Stationary at L12 | | | | |
| Accelerating downward | | | | |
| Constant speed downward | | | | |
| Decelerating at L1 | | | | |

### Calculations

Q5. Using the acceleration value from your Phyphox graph during the initial upward acceleration, calculate the expected normal force N. Compare with your measured scale reading.

$a$ = _________ m $s^{-2}$ (from Phyphox)    $N = m(g + a)$ =

Scale reading at this phase: _________ kg

Percentage difference = _________ %    Comment:

Q6. A 70 kg student is in a lift where the tension in the cable is 21,700 N and the combined mass of lift + passenger is 1,070 kg. Find the acceleration (magnitude and direction).

## E Analysis & Discussion

Q7. Sketch a free body diagram for the Scale Person at each of the three key phases below. Label the magnitudes of W and N and indicate whether N > W, N = W, or N < W.

| Accelerating upward | Constant velocity | Decelerating upward (approaching L12) |
|---|---|---|
| | | |

Q8. A person feels 'heavier' when the lift accelerates upward, even though their mass has not changed. As a group, write a concise physics explanation (3–4 sentences) using Newton's Second Law.

Q9. If the lift cable snapped and the lift entered free fall, what would the scale read? Justify with Newton's Second Law. What real-world phenomenon does this simulate?

Q10. Identify ONE limitation of using the weighing scale method and ONE limitation of using Phyphox in this experiment. Suggest one improvement for each.

| Method | Limitation | Suggested Improvement |
|---|---|---|
| Weighing scale | | |
| Phyphox app | | |

## F Group Reflection

Q11. Compare your Phyphox acceleration values with values derived from the scale readings ($a = N/m - g$). Do they agree? Discuss any discrepancies within your group.

Q12. The Phyphox altitude data comes from the barometer (air pressure). Using your altitude graph, estimate the height of each floor. How does it compare to the standard 3.5 m per floor?

Q13. Group consensus: Which method — Phyphox or weighing scale — gave more reliable data for this investigation? Give two reasons.

## G Extension (for early finishers)

| Challenge 1 | Challenge 2 |
| --- | --- |
| A lift of mass 600 kg carries passengers totalling 300 kg. The cable tension is 10 350 N. Find the acceleration. Is the lift speeding up or slowing down? In which direction is it travelling? | Plot N vs time for the full journey using your table from Part D. On the same axes, sketch the acceleration-time graph from Phyphox. Describe the relationship between the two graphs. |