ANSWER KEY - TEACHER COPY
Riding the Lift: Forces in Motion | Phone Sensor + Simulation Investigation

All answers below are model responses. Accept reasonable variations where observations depend on the phone model, browser, axis convention, or teacher-selected acceleration profile.

C Phone Sensor and Simulation Observation

Action	Expected observation	Interpretation
Phone held still and upright	One or more axes shows a steady reading related to support against gravity; values depend on phone orientation. The simulation should be stable or near equilibrium.	An accelerometer measures proper acceleration. A non-zero steady reading does not necessarily mean the phone is translating.
Phone tilted gently left/right	The acceleration components redistribute between axes; the pendulum / force display shifts direction.	Tilt changes the component of gravitational/support acceleration along each phone axis.
Small upward/downward hand motion	A brief transient change appears, then the reading returns close to the resting pattern.	Short motion produces acceleration only while the velocity is changing. Constant velocity would not produce the same transient.
Sensor unavailable	Simulation reports no accelerometer or shows slider mode.	The physics task can continue because slider mode provides a controlled model acceleration.

D Elevator Motion Model

Phase	a (m s^-2)	Velocity behaviour	Expected N relation
L1 -> L12: lift starts moving upward	+0.40	Increasing upward	N > W
L1 -> L12: constant speed upward	0	Constant upward	N = W
L1 -> L12: decelerates at L12	-0.40	Decreasing upward	N < W
Stationary at L12	0	Zero / stationary	N = W
L12 -> L1: lift starts moving downward	-0.40	Increasing downward	N < W
L12 -> L1: constant speed downward	0	Constant downward	N = W
L12 -> L1: decelerates at L1	+0.40	Decreasing downward	N > W

E Normal Force and Scale Reading

For m = 60 kg and g = 10 N kg^-1, W = 600 N.

Phase	a (m s^-2)	N = m(g + a)	Scale reading	Expected relation
Stationary at L1	0	60(10) = 600 N	60.0 kg	N = W
Accelerating upward	+0.40	60(10.40) = 624 N	62.4 kg	N > W
Constant speed upward	0	600 N	60.0 kg	N = W
Decelerating at L12	-0.40	60(9.60) = 576 N	57.6 kg	N < W
Stationary at L12	0	600 N	60.0 kg	N = W
Accelerating downward	-0.40	576 N	57.6 kg	N < W
Constant speed downward	0	600 N	60.0 kg	N = W
Decelerating at L1	+0.40	624 N	62.4 kg	N > W

Teacher Note
The same Newtonian pattern is preserved: high readings when acceleration is upward, normal readings when acceleration is zero, and low readings when acceleration is downward. This version uses browser sensor observation plus a clean simulation model, so students do not need a separate CSV-export workflow.

F Analysis & Discussion Model Responses

Q1	Acceleration determines the scale reading. Velocity tells whether the lift is moving up or down, but N changes only when there is net acceleration. For example, moving upward at constant speed gives N = W, but moving upward while slowing gives downward acceleration and N < W.

Q2	During the upward journey, the lift decelerates as it approaches Level 12. It is still moving upward, but acceleration is downward, so a < 0 and N < W.

Q3	N = m(g + a) = 60(10 + 0.40) = 624 N. Scale reading = 624 / 10 = 62.4 kg.

Q4	N = 60(10 - 0.40) = 576 N. Scale reading = 576 / 10 = 57.6 kg.

Q5	Accelerating upward: N arrow longer than W. Constant velocity: N and W equal. Decelerating upward: N arrow shorter than W. Both forces act on the person: W downward, N upward.

Q6	The person feels heavier because the floor/scale must exert a larger upward normal contact force to accelerate the person upward. The person's mass and gravitational weight mg have not increased; the contact force N has increased.

Q7	In free fall, a = -g. N = m(g - g) = 0, so the scale reads 0 kg. Gravity still acts; the person and lift accelerate downward together, so there is no support force from the scale.

Q8	Advantage: no CSV export or app installation is needed, and students can immediately see sensor/simulation response. Limitation: browser motion access may be blocked, phone axes vary, and the readings are usually qualitative/noisy rather than clean exported data.

Q9	Advantage: an idealised simulation makes acceleration phases and force relationships clearer. Limitation: it removes real-world effects such as vibration, sensor noise, lift jerk, display lag, and imperfect phone orientation.

Q10	Accept reasoned answers. Strong responses say calculations are most precise for N values, simulation is best for visualising the model, and phone sensor observations are best for connecting physics to a real device. Students should justify with at least two concrete reasons.

G Extension Answers

Challenge	Answer
1	For m = 70 kg and a = +0.80 m s^-2: N = 70(10.80) = 756 N. Scale reading = 756 / 10 = 75.6 kg.
2	Moving downward but slowing down means acceleration is upward. Therefore N > W, so the N arrow is longer than W.
3	Real phone signals are affected by hand tremor, sensor sampling rate, browser filtering, phone-axis orientation, and the fact that the accelerometer measures proper acceleration rather than simply "motion."

Key Equations
F_net = ma | N - mg = ma => N = m(g + a) | Scale-derived a = N/m - g | Free fall: N = 0

Simulation link

Open the live elevator phone accelerometer simulation: 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.