a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

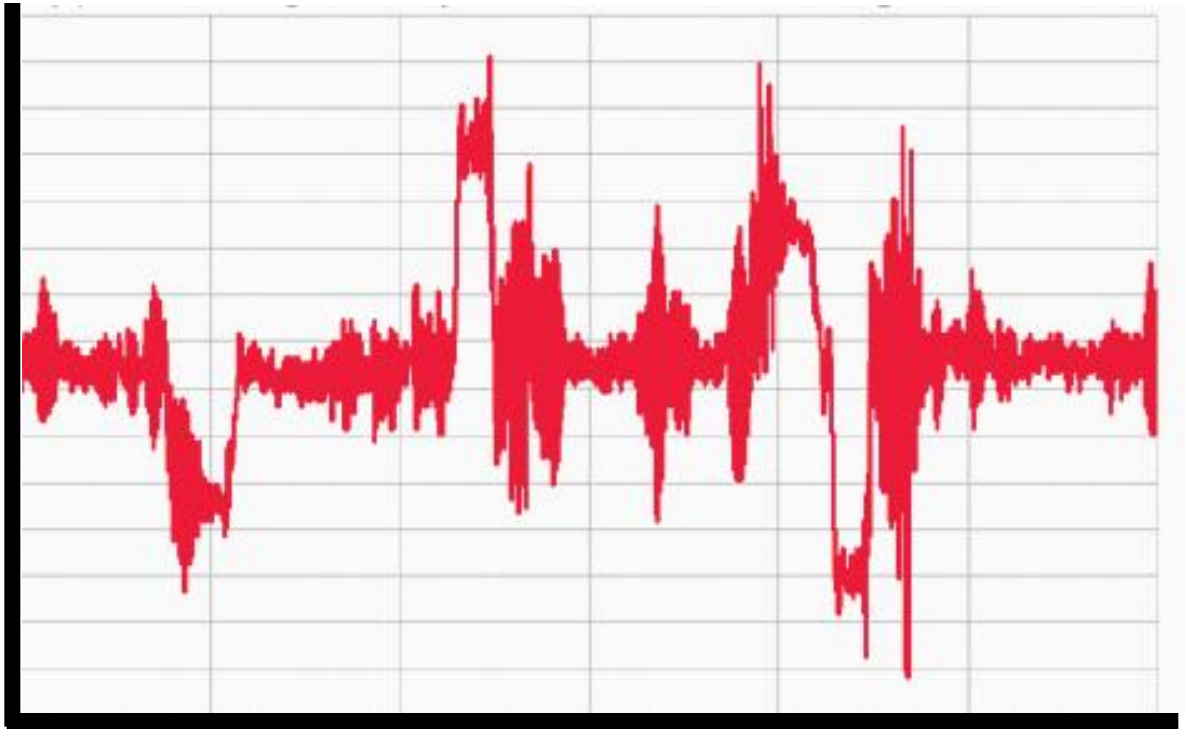
Physics
Dynamics: Weight

Science and Mathematics Education Research Group

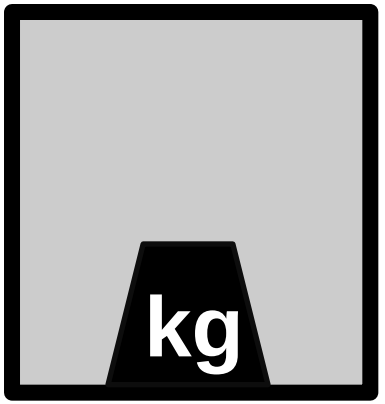
Supported by UBC Teaching and Learning Enhancement Fund 2012-2013

Weight in an Elevator

F



t

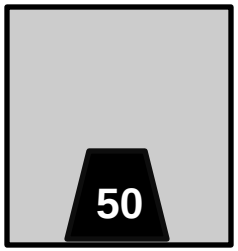


a = ?

Weight in an Elevator I

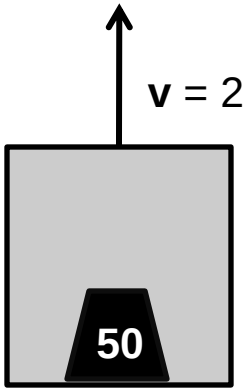
A 50 kg mass is put onto a scale in an elevator moving at constant velocity. In which elevator will the scale have the greatest reading?

A.

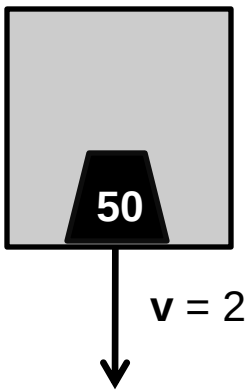


v = 0 m/s

B.



C.



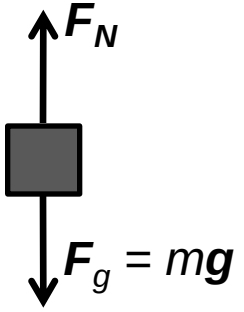
D. The scale will have the same reading in all three elevators

Solution

Answer: D

Justification: Although scales read in units of kg, they are really measuring how much force (in N) the scale is exerting on the mass. This is the normal force. Since all 3 elevators are moving at constant velocity, there is no net force acting on the mass. By $\overrightarrow{F_{net}} = m\vec{a}, \overrightarrow{F_{net}} = 0$

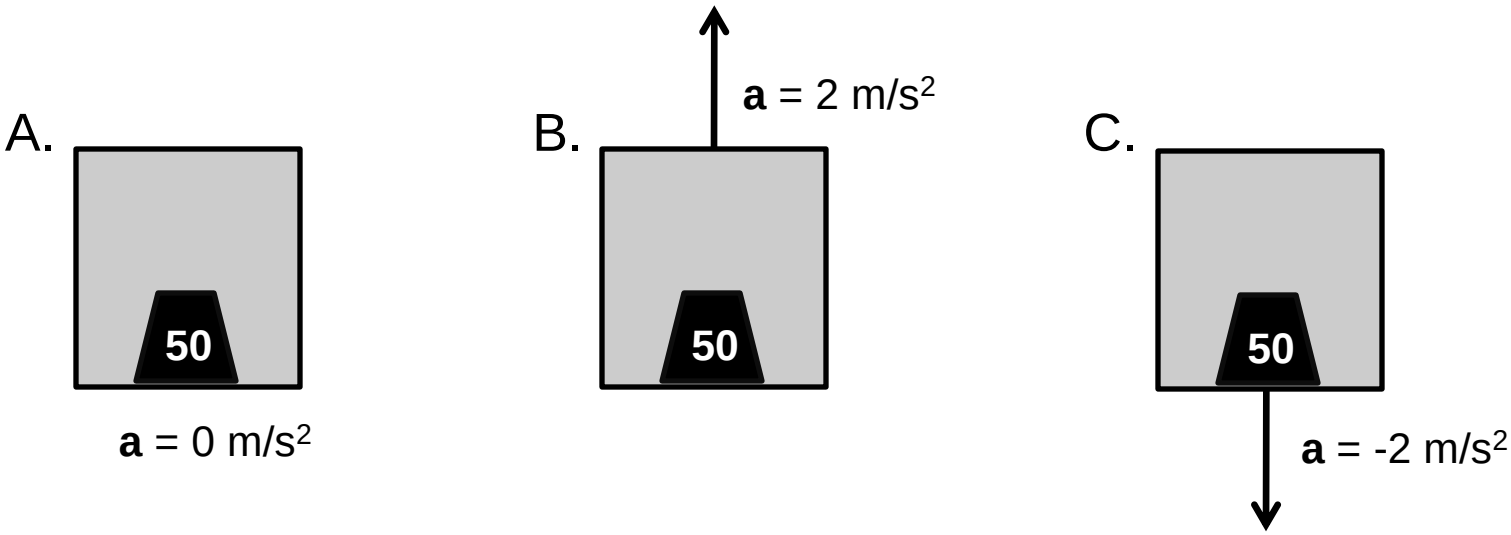
Therefore the normal force will be equal to the force of gravity on the mass in all 3 cases.



$|F_N| = |mg| = 500$ N

Weight in an Elevator II

A 50 kg mass is put onto a scale in an elevator. In which elevator will the scale have the greatest reading?



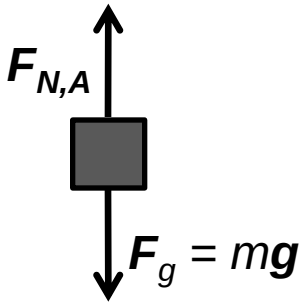
D. The scale will have the same reading in all three elevators

E. Cannot determine without initial velocities

Solution

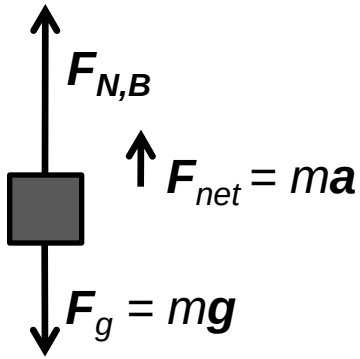
Answer: B

Justification: Scale B experiences a net force in the upwards direction. Thus $F_{N,B}$ must be larger than mg. On the other hand, scale C experiences a downwards net force so $F_{N,C}$ is smaller than mg.



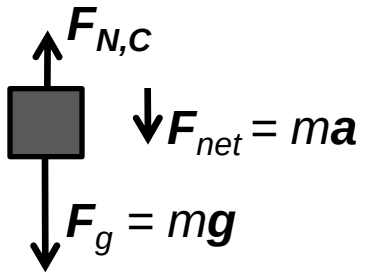
$F_{net} = F_{N,A} + F_g = 0$ N

$F_{N,A} = F_g$



$F_{net} = F_{N,B} + F_g > 0$

$F_{N,B} > F_g$

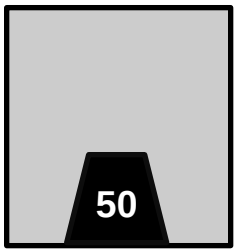


$F_{net} = F_{N,C} + F_g < 0$

$F_{N,C} < F_g$

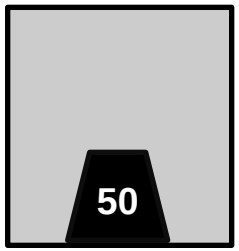
Weight in an Elevator III

Rank the elevators from the largest scale reading to the smallest scale reading.

1. 

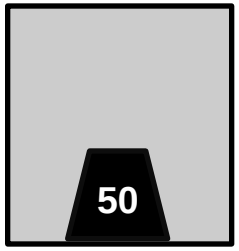
v = 0 m/s

a = 0 m/s^2

2. 

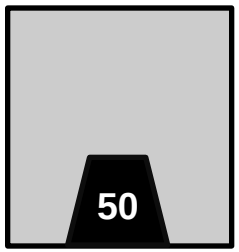
v = 2 m/s ↑

a = 2 m/s^2 ↑

3. 

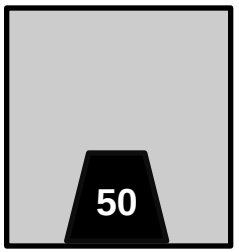
v = 2 m/s ↑

a = 2 m/s^2 ↓

4. 

v = -2 m/s ↓

a = 2 m/s^2 ↑

5. 

v = -2 m/s ↓

a = 2 m/s^2 ↓

A. 2 > 3 > 1 > 4 > 5

B. 2 = 3 > 1 > 4 = 5

C. 3 > 2 > 1 > 5 > 4

D. 2 = 4 > 1 > 3 = 5

E. 3 = 5 > 1 > 2 = 4

Solution

Answer: D

Justification: From question I, we learned that scales measure force. By $\overrightarrow{F_{net}} = m\vec{a}$, objects of the same mass with the same acceleration will experience equal net forces. Therefore, 2 = 4 and 3 = 5.

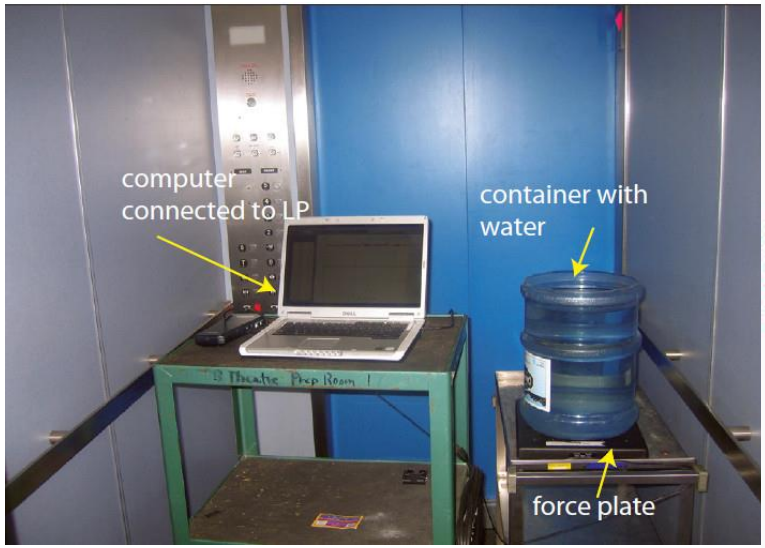
After grouping 2 = 4 and 3 = 5, this question becomes the same as question II.

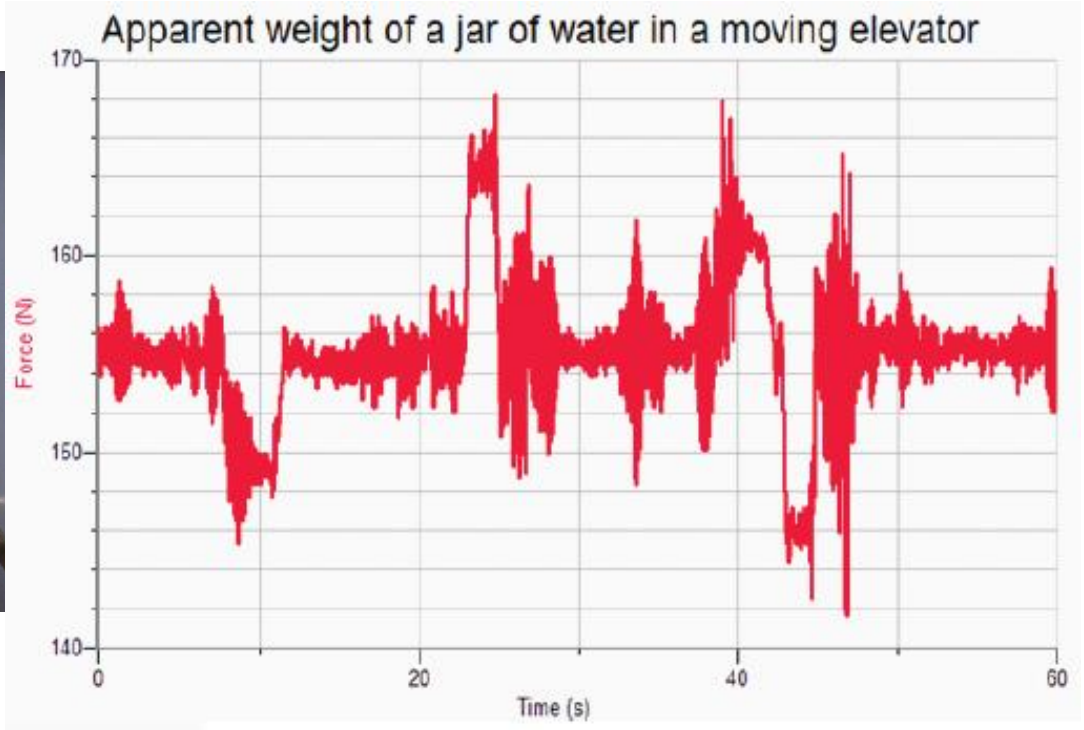
We learned that an upwards acceleration will cause a larger normal force, and thus a larger reading on the scale.

Therefore, 2 = 4 > 1 > 3 = 5

Real-Life Experiment

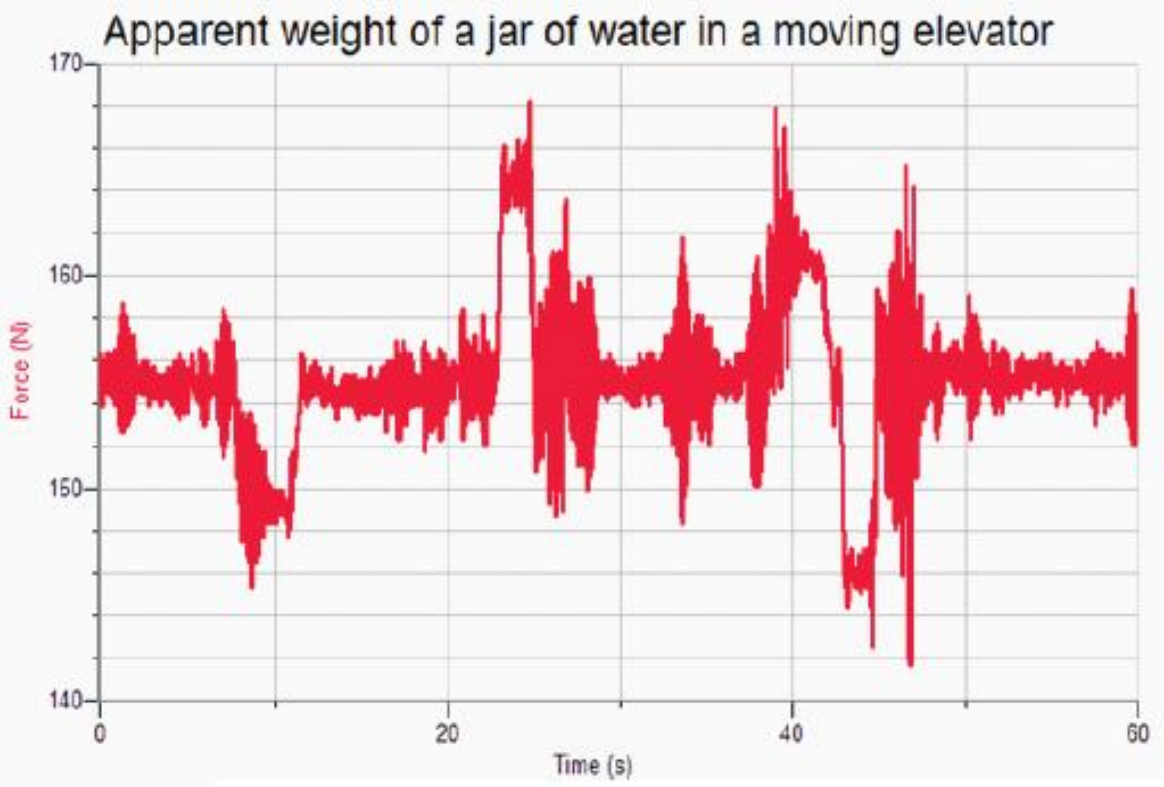
A jar of water on a force plate is placed into an elevator. Using Logger Pro (LP), the apparent weight of the water can be plotted as a function of time. The graph below shows the results of the experiment.





Real-Life Experiment I

Which of the following is the best estimate for the mass of the jar of water? Assume g = 10 m/s^2.



A. 15.5 kg

B. 15.5 N

C. 155 kg

D. 155 N

E. None of the above

Solution

Answer: A

Justification: The graph suggests that the elevator is not accelerating during the large, flat sections. In these instances, the normal force is equal to the gravitational force. From the graph, estimate the force is 155 N.

$$|\mathbf{F}_N| = m|\mathbf{g}|$$

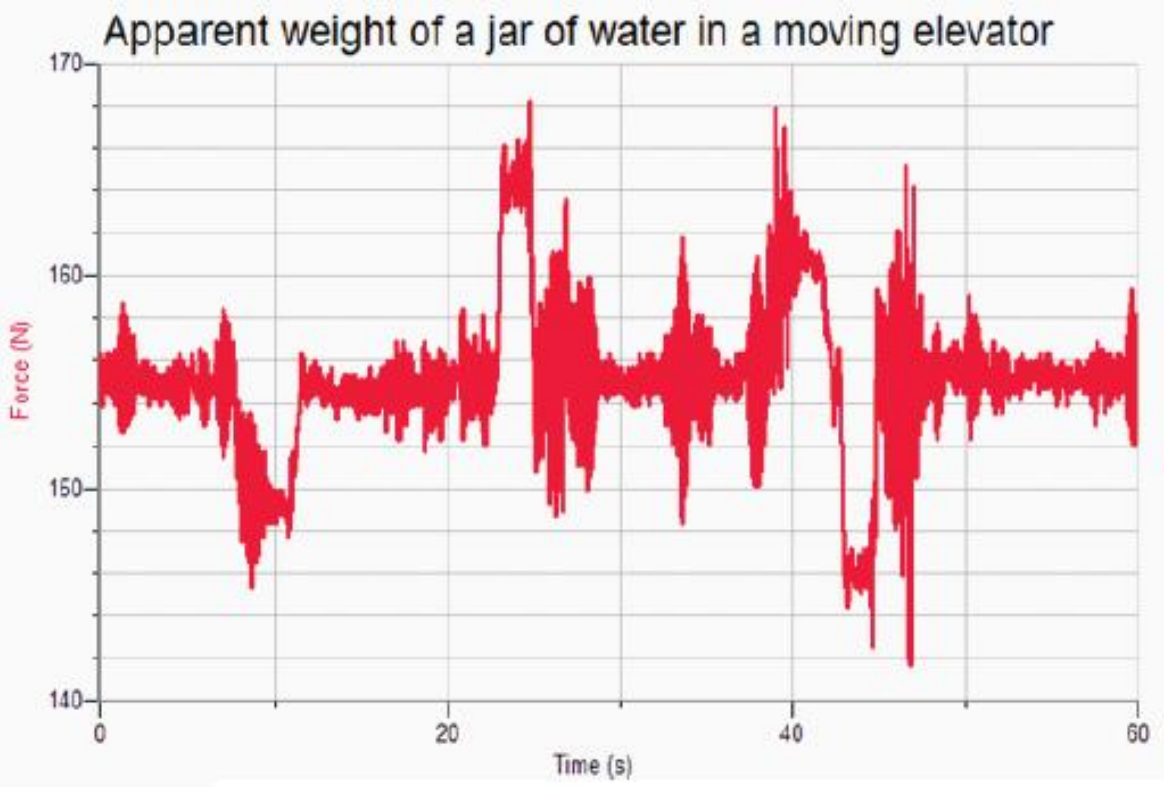
$$m = \frac{155\ \text{N}}{10\ \text{m/s}^2}$$

$$m = 15.5\ \text{kg}$$

The Newton is a unit of force, not mass, so B and D must be incorrect. C is off by a factor of ten – don't forget acceleration due to gravity!

Real-Life Experiment II

What is the maximum magnitude of acceleration of the elevator?

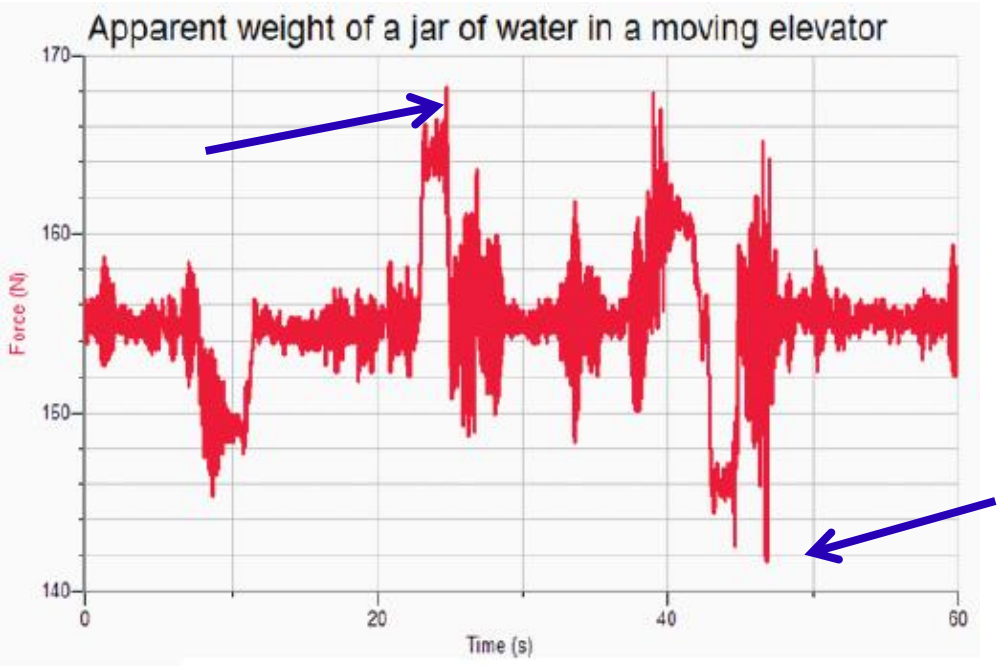


A. 0 m/s^2
B. ~ 0.4 m/s^2
C. ~ 0.8 m/s^2
D. ~ 1.2 m/s^2
E. Not enough information

Solution

Answer: C

Justification: The maximum magnitude of acceleration can be found at the time when the weight is at its maximum (167 N at 24 s) or its minimum (143 N at 43s).

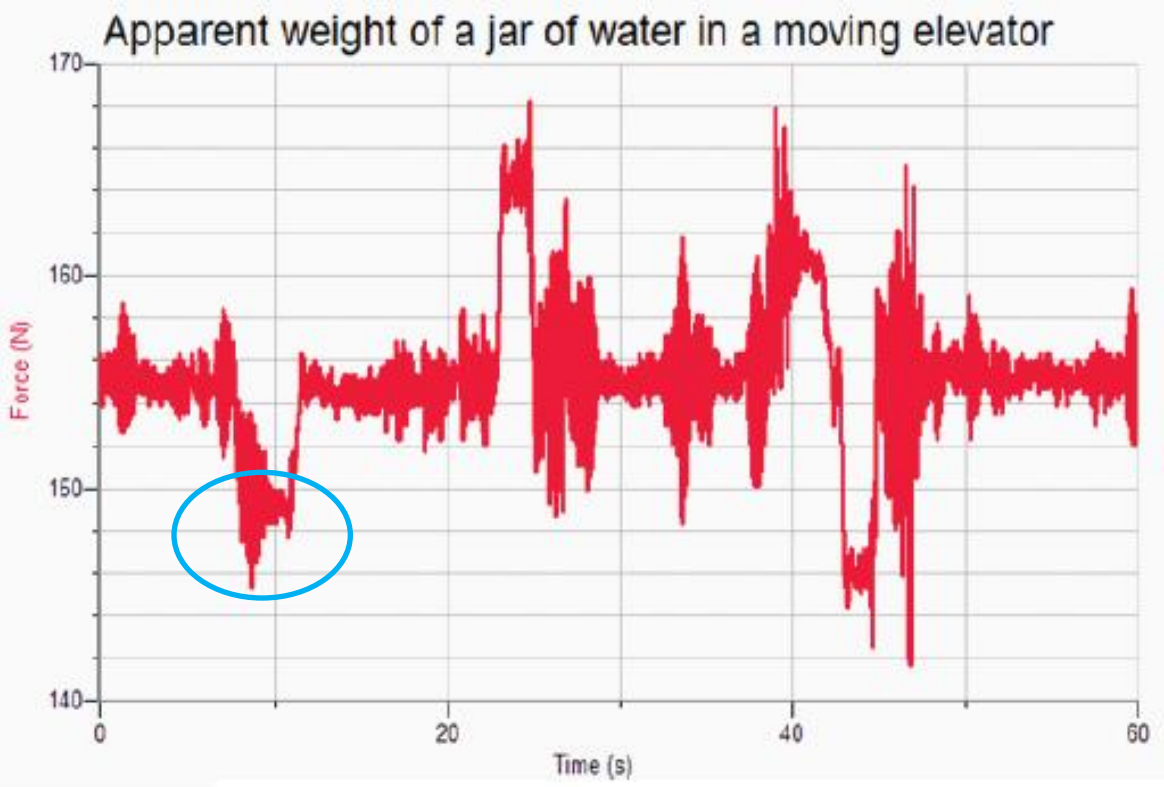


Using either of these values gives:

$$|a| = \frac{|F_N - mg|}{m} \approx \frac{12\ \text{N}}{15.5\ \text{kg}} = 0.8\ \text{m/s}^2$$

Real-Life Experiment III

Consider the time period from 8 s to 11 s. Which of the following best describe the speed of the elevator?



A. Increasing speed
B. Constant speed
C. Decreasing speed
D. Either A or C
E. None of the above

Solution

Answer: D

Justification: Since the measured weight is lower than when the elevator is moving at constant velocity, the elevator must be accelerating downwards. Consider the following 2 cases of downwards acceleration:

Case 1: The elevator starts at rest (or with a constant downwards velocity) when t = 0 s. At 8 s, when the elevator begins accelerating downward, the elevator is *speeding up* while moving downwards.

Case 2: The elevator starts with a constant upwards velocity when t = 0 s. At 8 s, when the elevator begins accelerating downward, the elevator is *slowing down* while still moving upwards.

Both of these cases will produce the same graph as in the experiment.