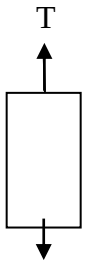
# Elevator Problems

Free-Body Diagram of an elevator at rest (person and elevator).

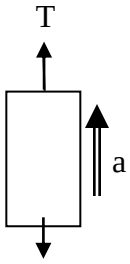



$$T - Mg = 0$$
$$\therefore T = Mg$$

$$F_N - mg = 0$$
$$\therefore F_N = mg$$

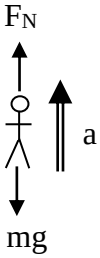
**or apparent weight**


Free-Body Diagram of an elevator accelerating upward (person and elevator)

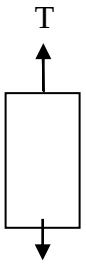



$$T - Mg = Ma$$
$$\therefore T = M(g + a)$$

$$F_N - mg = ma$$
$$\therefore F_N = m(g + a)$$



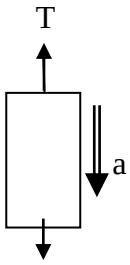

Free-Body Diagram of an elevator moving at constant velocity (person and elevator).




$$T - Mg = 0$$
$$\therefore T = Mg$$

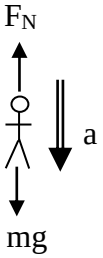
$$F_N - mg = 0$$
$$\therefore F_N = mg$$


Free-Body Diagram of an elevator accelerating downward (person and elevator)




$$Mg - T = Ma$$
$$\therefore T = M(g - a)$$

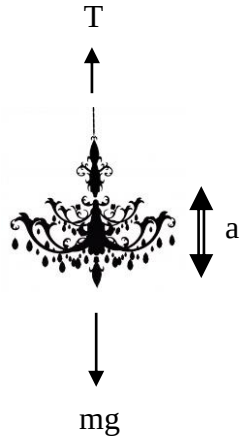
$$mg - F_N = ma$$
$$\therefore F_N = m(g - a)$$




Free-Body Diagram of a weight hanging from a scale, or a chandelier, on an elevator moving at constant velocity (or at rest).


$$T - mg = 0$$
$$\therefore T = mg$$

Free-Body Diagram of a weight hanging from a scale, or a chandelier, on an elevator accelerating upward (or downward).




**Accelerating up:**

$$T - mg = ma$$
$$\therefore T = m(g + a)$$

**Accelerating down:**

$$mg - T = ma$$
$$\therefore T = m(g - a)$$

## Homework Problems

0) A girl is standing in an elevator with a scale beneath her feet, being used to measure her weight. For an unknown, seemingly strange reason, a fish is hanging from a spring scale on the ceiling above her head.

   a) Does the scale read more than, less than, or exactly her weight when the elevator accelerates upward?
   b) Does the scale read the fish's weight correctly when the elevator is moving at a constant velocity? Explain.
   c) What kind of elevator motion would it take for the spring scale to break due to too much tension?
   d) What happens to the reading on the scale if the rope that moves the elevator were to suddenly snap, sending the elevator into free-fall?

1. A 40 kg girl is riding in an elevator while standing on a scale.

   a) Sketch a free-body diagram of the girl with all forces shown.
   b) What is her apparent weight (scale reading) when the elevator is accelerating upward at 2 $m/s^2$?
   c) What is her apparent weight when the elevator is accelerating downward at 2 $m/s^2$?
   d) When the scale reads 392 N, what is/are her motion conditions?

2. A 20 kg chandelier is hanging from the top of an elevator ceiling. The chain which it hangs from is rated to handle 279 N of tension.

   a) Determine the greatest acceleration of the elevator without the chain breaking, causing the chandelier to fall.
*** b) If the elevator was accelerating upward at 6.2 $m/s^2$ and the chandelier did fall, how much time would it take to hit the floor? (there is 4 meters between the floor and the bottom of the chandelier)

3. A test space ship causes its pilots to feel an acceleration of 2 g's while launching straight up from the Earth. This means that the astronauts feel "twice" their own weight (one g is regular weight). Determine the acceleration of the space ship.

4. A tall man with a red tie is riding up in an elevator. He realizes that he is standing on a scale, which reads 686 N, while the elevator is at rest.

   b) When the elevator begins to move, the scale reads 476 N. Determine the acceleration of the elevator.
   c) How long will it take for the elevator to reach a speed of 12 m/s?

5. A passenger in an elevator has a mass of 100 kg. Calculate the force, in newtons, exerted on the passenger by the elevator, if the elevator is:
   a) at rest
   b) moving with an upward acceleration of 30 $cm/s^2$
   c) moving with a downward acceleration of 15 $cm/s^2$
   d) moving upward with an uniform velocity of 15 cm/s
   e) falling freely (the cable breaks)

6. A man measures the acceleration of an elevator by using a spring balance. He fastens the scale to the roof, and suspends a mass from it. If the scale reads 98 N when the elevator is at rest, and 93 N when the elevator is moving:
   a) what is the acceleration of the elevator?
   b) in which direction is the elevator accelerating?

7. An man is standing in an elevator on a set of spring scales calibrated in newtons. Suppose the elevator accelerates upward at 3.0 $m/s^2$.
   a) If the scale reads 1,024N, what is the man's mass?
   b) If the elevator has a mass of 1000 kg, and if the scale has a mass of 10 kg, find the tension in the elevator's cable (you know, the one that is pulling the elevator upward)

Answers

0) Answers in class.
1) 472 N, 312 N, at rest or moving at a constant velocity.
2) 4.15 $m/s^2$ upward, .71 seconds
3) 9.8 $m/s^2$ upward
4) 3 $m/s^2$ downward; 4 sec
5) 980N; 1,010N; 965N; 980N, 0N
6) 0.5 $m/s^2$ ; downward
7) 80 kg ; 13,952 N