Newton's Second Law and an Elevator

There are 4 separate scenarios in this problem, described below. Assume that a person in an elevator has a weight W = 700 N. The person is standing on a scale that is not moving **relative to the elevator**, and the person remains in contact with the scale at all times. You **MUST** include the correct units for answers requiring numerical values. **For all of the scenarios assume that the positive y-axis points upward.**

The conditions for scenarios a, b, c, and d are:

a) The normal force (scale reading) is F_{scale} = 700 N, there is zero acceleration, meaning that v = constant.
b) The normal force (scale reading) is F_{scale} = 1,000 N, there is an upward, constant acceleration.
c) The normal force (scale reading) is F_{scale} = 400 N, there is a downward, constant acceleration.
d) The normal force (scale reading) is F_{scale} = 0 N, and the elevator, person, and scale are in a state of freefall, a = g.

1) Draw the free-body diagram for each example. The diagram should include all of the forces acting on the object and the direction of the acceleration vector, provided that the acceleration is not zero. If the object is not accelerating, be sure and indicate that using $\vec{a} = \vec{0}$. You are not including numerical values on these diagrams and there is no partial credit for a scenario. (4 points)

   a) b)

   c) d)

2) Apply Newton's 2nd Law to the general situation. Write **one general equation** that represents all of the scenarios above in terms of **only** these variables: the force F_{scale} indicated on the scale, the man's weight *W*, the man's mass *m*, the acceleration *a* of the elevator, and the acceleration of gravity *g*. (1 point)

$$F_{scale} - W = ma \quad \text{or} \quad F_{scale} = W + ma \quad \text{or} \quad F_{scale} = mg + ma \quad \text{or} \quad F_{scale} = mg + \frac{W}{g}a \quad \text{or} \quad W = F_{scale} - ma$$

3) Solve this equation for the acceleration variable *a*. No credit for this question if the answer to question 2) is incorrect. (1 point)

$$a = \frac{F_{scale} - W}{m}$$

4) Write the **numerical value** of the magnitude of the normal force F_{scale} for each example. (4 points)

   a) $F_{scale} = 700\ N$

   c) $F_{scale} = 400\ N$

   b) $F_{scale} = 1{,}000\ N$

   d) $F_{scale} = 0\ N$

5) Calculate the **numerical value** of the magnitude of the acceleration *a* for each example, and be sure to indicate whether the value is positive, negative, or zero. (4 points)

$$m = \frac{W}{g} = \frac{700\ N}{9.81\ m/s^2} = 71.4\ kg$$

   a) $a = \dfrac{700\ N - 700\ N}{71.4\ kg} = 0.0\ m/s^2$

   c) $a = \dfrac{400\ N - 700\ N}{71.4\ kg} = -4.2\ m/s^2$

b) $a = \frac{1{,}000\ N - 700\ N}{71.4\ kg} = 4.2\ m/s^2$

d) $a = \frac{0\ N - 700\ N}{71.4\ kg} = 9.8\ m/s^2$