# Finding the Force on an Elevator Cable when:

**I.** The elevator is at rest

**II.** The elevator accelerates upward from rest

**III.** The elevator accelerates downward from rest

**IV.** The elevator is moving at a constant velocity

**V.** The elevator is moving upward and comes to rest

**VI.** The elevator is moving downward and comes to rest

*There are 2 approaches for solving this problem using forces:*

**Method I**
*Determine the sign of the acceleration and incorporate it into the force and kinematic equations*

**Method II**
*Assume the acceleration is positive in F = ma for all cases and then let its sign be determined from the kinematic equations based on the information given in the problem*

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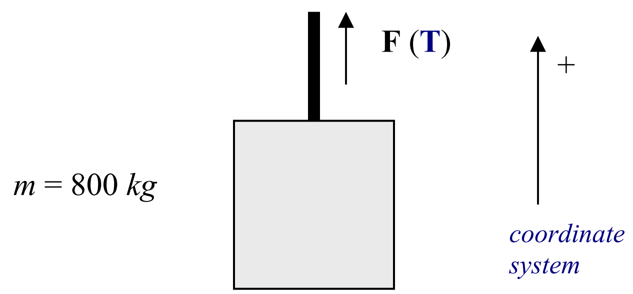
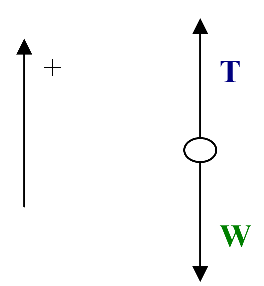
# Method I




*Whenever a force is directed along a linear object such as a cable, string…it is typically referred to as the **Tension** (force), **T**.*

## I. The elevator is at rest

The forces acting on the elevator can be represented by:




$v_o = 0\ m/s$

$v = 0\ m/s$

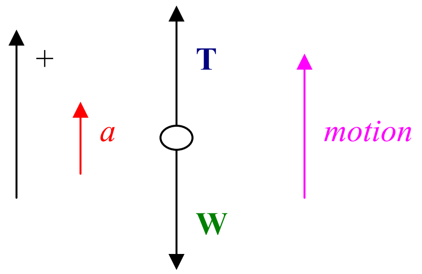
$a = 0\ m/s^2$

$\sum F = 0$

$T - mg = 0 \quad \rightarrow \quad T = mg$

$= (800\ kg)(9.8\ m/s^2)$ **= 7840 N**

## II. The elevator accelerates upward from rest




$v_o = 0\ m/s$

$v = 10\ m/s$ after moving 25 $m$

$$\sum F = ma$$

$T - mg = ma$ (***note***: *ma* is positive since *a* is in the + direction)

➔ $T = m(g + a)$

* Need value of *a*:

| Given | Needed |
|---|---|
| $v_o$ $v$ $\Delta x$ | $a$ |

➔ $v^2 = v_o^{\,2} + 2a\Delta x$

*Solving for a*:

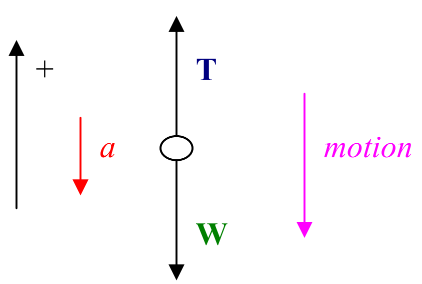
$$a = \frac{v^2}{2\Delta x} = \frac{(10\,\frac{m}{s})^2}{2(25m)}$$

$a = 2\ m/s^2$

*Therefore*, $T = m(g + a)$

$= (800\ kg)(9.8\ m/s^2 + 2\ m/s^2)$ **= 9440 N**

## III. The elevator accelerates downward from rest




$v_o = 0\ m/s$

$v = 10\ m/s$ after moving 25 $m$

$$\sum F = ma$$

$T - mg = -\,ma$ (***note***: *ma* is negative since *a* is in the – direction)

➔ $T = m(g - a)$

* Need value of $a$:

| Given | Needed |
| --- | --- |
| $v_o$   $v$   $\Delta x$ | $a$ |

➔   $v^2 = v_o^2 - 2a\Delta x$   (*noting that* $a < 0$)

*Solving for* $a$:

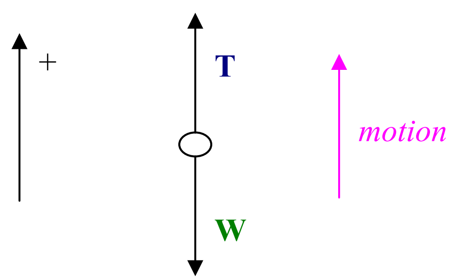
$$a = \frac{-v^2}{2\Delta x} = \frac{-(10\,\frac{m}{s})^2}{2(-25m)}$$   (*note*: $\Delta x < 0$ *since motion is in the – direction*)

$a = 2\ m/s^2$

*Therefore*, $T = m(g - a)$

$= (800\ kg)(9.8\ m/s^2 - 2\ m/s^2)$ **= 6240 N**

## IV. The elevator is moving at a constant velocity




$v_o = 10\ m/s = constant$ ➔ $a = 0\ m/s^2$

$$\sum F = 0$$

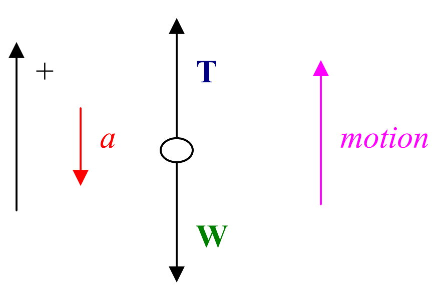
$T - mg = 0$ ➔ $T = mg$

$= (800\ kg)(9.8\ m/s^2)$ **= 7840 N**   (*same as if the elevator was at rest!*)

*** Would the result be different if the direction of motion were reversed?*

**No!**

## V. The elevator is moving upward and comes to rest




$v_o = 10\ m/s$

$v = 0\ m/s$ after moving 25 $m$

$\sum F = ma$

$T - mg = -ma$ (***note***: *ma* is negative since *a* is in the – direction)

➔ $T = m(g - a)$

* Need value of *a*:

*Use* $v^2 = v_o^2 - 2a\Delta x$ (*noting that* $a < 0$)

*Solving for a*:

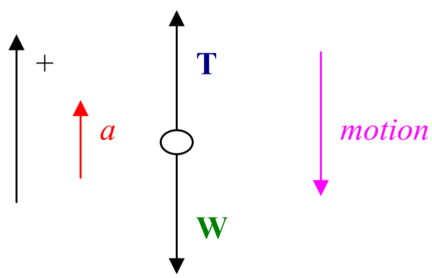
$$a = \frac{v_o^2}{2\Delta x} = \frac{(10\,\frac{m}{s})^2}{2(25m)}$$

$a = 2\ m/s^2$

*Therefore*, $T = m(g - a)$

$= (800\ kg)(9.8\ m/s^2 - 2\ m/s^2)$ **= 6240 N**

## VI. The elevator is moving downward and comes to rest




$v_o = 10\ m/s$

$v = 0\ m/s$ after moving 25 *m*

$\sum F = ma$

$T - mg = ma$ (***note***: *ma* is positive since *a* is in the + direction)

➔ $T = m(g + a)$

* Need value of *a*:

*Use* $v^2 = v_o^2 + 2a\Delta x$ (*noting that* $a > 0$)

*Solving for a*:

$$a = \frac{-v_o^2}{2\Delta x} = \frac{-(10\,\frac{m}{s})^2}{2(-25m)}$$

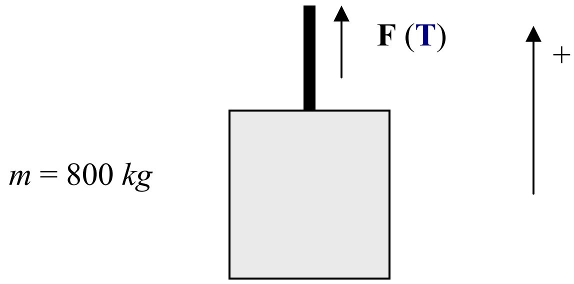
(*note*: $\Delta x < 0$ *since motion is in the – direction*)

$a = 2\ m/s^2$

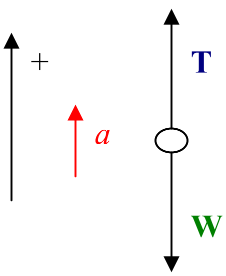
*Therefore*, $T = m(g + a)$

$= (800\ kg)(9.8\ m/s^2 + 2\ m/s^2)$ **= 9440 N**

## Method II




For all cases, let the forces representing the system be given by:




$$\sum F = ma$$

$T - mg = ma$ (***note***: $ma$ is <u>positive</u> since $a$ is in the + direction)

➔ $\mathbf{T = m(g + a)}$

* Need value of $a$:

### I. The elevator is at rest

$a = 0\ m/s^2$

➔ $T = mg$

$= (800\ kg)(9.8\ m/s^2)$ **= 7840 N**

### II. The elevator accelerates upward from rest

| Given | Needed |
|---|---|
| $v_o$ $v$ $\Delta x$ | $a$ |

➔ $v^2 = v_o^2 + 2a\Delta x$

*Solving for a*:

$$a = \frac{v^2}{2\Delta x} = \frac{(10\,\frac{m}{s})^2}{2(25m)}$$

$a = 2\ m/s^2$

*Therefore*, $T = m(g + a)$

$= (800\ kg)(9.8\ m/s^2 + 2\ m/s^2)$ **= 9440 N**

## III. The elevator accelerates downward from rest

*Using* $v^2 = v_o^{\,2} + 2a\Delta x$

$$a = \frac{v^2}{2\Delta x} = \frac{(10\,\frac{m}{s})^2}{2(-25m)}$$ (*note*: $\Delta x < 0$ *since motion is in the – direction*)

$a = -2\ m/s^2$

*Therefore*, $T = m(g + a)$

$= (800\ kg)(9.8\ m/s^2 - 2\ m/s^2)$ **= 6240 N**

## IV. The elevator is moving at a constant velocity

$a = 0\ m/s^2$ (*regardless of direction*)

➔ $T = mg$

$= (800\ kg)(9.8\ m/s^2)$ **= 7840 N**

## V. The elevator is moving upward and comes to rest

*Using* $v^2 = v_o^{\,2} + 2a\Delta x$

$$a = \frac{-v_o^{\,2}}{2\Delta x} = \frac{-(10\,\frac{m}{s})^2}{2(25m)}$$

$a = -2\ m/s^2$

*Therefore*, $T = m(g + a)$

$= (800\ kg)(9.8\ m/s^2 - 2\ m/s^2)$ **= 6240 N**

## VI. The elevator is moving downward and comes to rest

*Using* $v^2 = v_o^{\,2} + 2a\Delta x$

$$a = \frac{-v_o^{\,2}}{2\Delta x} = \frac{-(10\,\frac{m}{s})^2}{2(-25m)}$$ (*note*: $\Delta x < 0$ *since motion is in the – direction*)

$a = 2\ m/s^2$

*Therefore*, $T = m(g + a)$

$= (800\ kg)(9.8\ m/s^2 + 2\ m/s^2)$ **= 9440 N**