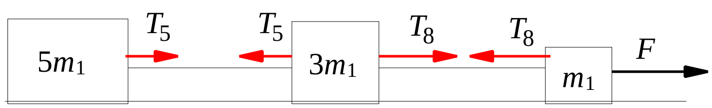
1. Which condition is impossible:

a) acceleration equal to zero, and velocity <u>not</u> equal to zero.
b) acceleration <u>not</u> equal to zero, and velocity equal to zero. (ball at highest point)
c) acceleration <u>not</u> equal to zero, and velocity <u>not</u> equal to zero.
d) acceleration equal to zero, and velocity equal to zero.
e) none of the above.

2. A mass weighs 10,000 N on the planet Mongo ($g_{\text{Mongo}} = 25\text{N/kg}$). What is its weight on the Earth?

$$m = \frac{W_{Mongo}}{g_{Mongo}} = \frac{W_{Earth}}{g_{Earth}}; \quad W_{Earth} = \frac{g_{Earth}}{g_{Mongo}} W_{Mongo} = \frac{10\text{ N/kg}}{25\text{ N/kg}}(10{,}000\text{ N}) = \underline{4{,}000\text{ N}}$$

a) 250,000 N b) 400 N c) 2.5 N d) 4000 N e) 2500 N



Picture for problems 3-4

3. A force F accelerates three masses tied together with strings along a frictionless surface as shown in the figure above. What is the acceleration of each mass?

a) $\frac{F}{3m_1}$ b) $\frac{F}{5m_1}$ c) $\frac{F}{8m_1}$ d) $\frac{F}{9m_1}$ e) $\frac{F}{10m_1}$

The force **F** must accelerate all three masses ($9m_1$)

$$\mathbf{F} = m\mathbf{a} = 9m_1\mathbf{a}$$
$$\mathbf{a} = \frac{\mathbf{F}}{9m_1}$$

4. What is the net force acting on the middle mass?

a) F b) $\frac{F}{2}$ c) $\frac{F}{3}$ d) $\frac{F}{4}$ e) $\frac{F}{6}$

$$(\textit{net}\text{ force on middle mass})\ \mathbf{F} = m\mathbf{a} = (3m_1)\left(+\frac{F}{9m_1}\right) = +\frac{F}{3}$$

Alternate Solution to Problem 4.

4. What is the net force acting on the middle mass?

a) F b) $\frac{F}{2}$ c) $\frac{F}{3}$ d) $\frac{F}{4}$ e) $\frac{F}{6}$

The tension $\mathbf{T}_5$ must accelerate the last mass, ($5m_1$). The tension $\mathbf{T}_8$ must accelerate the last two masses ($8m_1$). The acceleration **a** is the same for each mass.

$$T_5 = 5m_1 a \quad \text{and} \quad T_8 = 8m_1 a$$

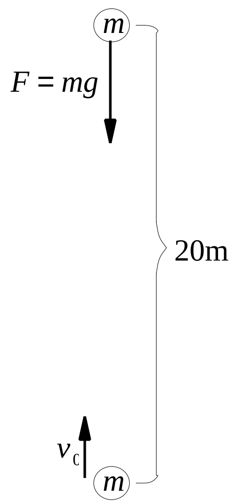
Acting on the central mass are the force vectors:

$$\mathbf{T}_5 = -5m_1 a \quad \text{and} \quad \mathbf{T}_8 = +8m_1 a$$

The net force acting on the central mass is the sum of these vectors:

$$\begin{aligned} F_{net} &= \mathbf{T}_5 + \mathbf{T}_8 = (-5m_1 a) + (+8m_1 a) \\ &= 3m_1 a = 3m_1\left(\frac{F}{9m_1}\right) = \frac{F}{3} \end{aligned}$$

A ball with a mass of 2kg is thrown up (+ direction) into the air (ignore air friction).



$m = 2\text{kg}$

(Draw this situation in the right margin, including the vectors asked for below)

5. What force acts on the ball at the highest point? magnitude <u>*mg*</u>, direction <u>downward (–)</u>

6. What is the acceleration (both magnitude and direction) of the ball,

   at the highest point? (magnitude <u>*g*</u> and direction <u>downward (–)</u> ,
   on the way up? (magnitude <u>*g*</u> and direction <u>downward (–)</u>,
   on the way down? (magnitude <u>*g*</u> and direction <u>downward (–)</u>

7. If the ball is thrown to a height of 20m above your hand, how long will it take to get back to your hand? <u>4 seconds</u>

(first find initial velocity v_0)

$$v^2 - v_0^2 = 2\mathbf{a}\ \mathbf{s} = 2(-g)\ \mathbf{s}$$
$$-v_0^2 = -2(10\text{m / s}^2)(+20\text{ m}) = -400\text{ m}^2/\text{s}^2$$
$$v_0 = 20\text{ m / s}\ ;\ \mathbf{v}_0 = +20\text{ m / s}$$

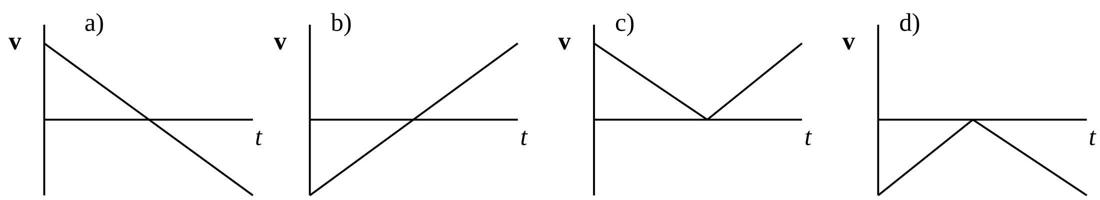
(then find time)

$$\mathbf{s} = \mathbf{v}_0 t + \tfrac{1}{2}\mathbf{a}t^2$$
$$0 = \mathbf{v}_0 t - \tfrac{1}{2}gt^2$$
$$t = \frac{2\mathbf{v}_0}{g} = \frac{40\text{ m / s}}{10\text{ m / s}^2} = 4\text{ s}$$

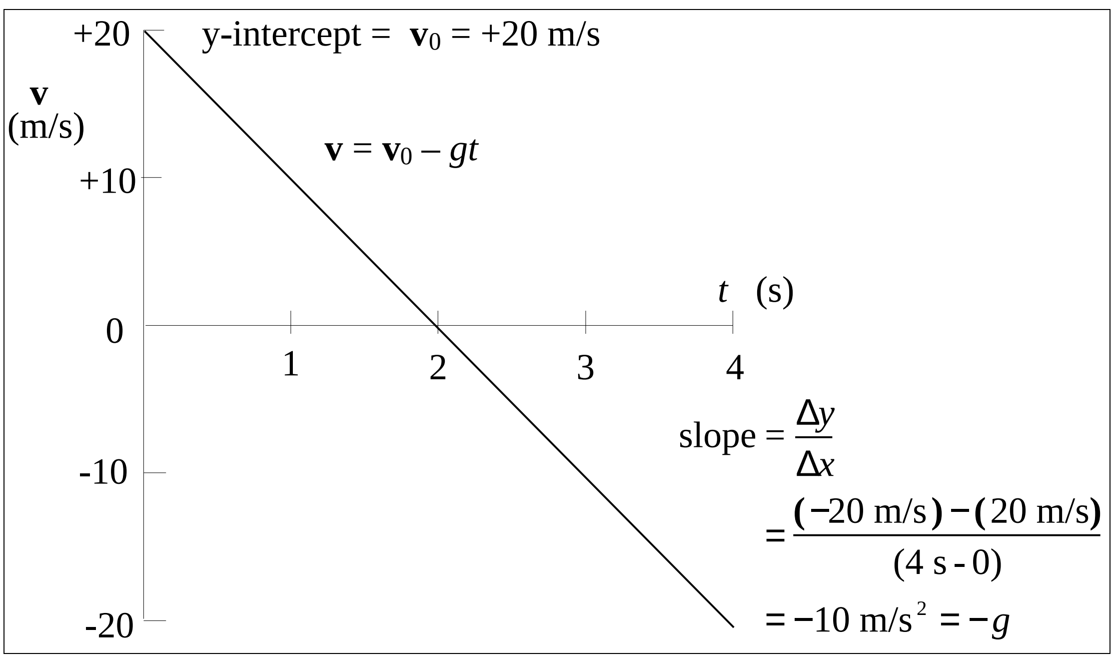
8. What will be the speed of the ball when it hits your hand? <u>20 m/s</u>

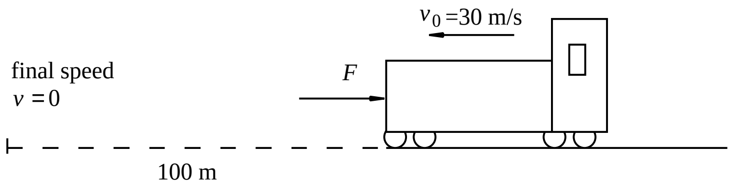
$$\mathbf{v} = \mathbf{v}_0 - gt$$
$$= (+20 \text{ m/s}) - (10 \text{ m/s}^2)(4 \text{ s})$$
$$= -20 \text{ m/s}$$
$$v = \underline{20 \text{ m/s}}$$

9. Which graph below describes the velocity vs. time for this motion? <u>Graph a</u>
What are the slope, $\underline{-g}$, and intercept, $\underline{\mathbf{v}_0 = +20 \text{ m/s}}$, of the line on the graph?
(see motion equations above).



e) none of the above





A train weighing 10^6N, moving with a speed of 30 m/s, is slowed to $v = 0$, in a distance of 100 m, by an applied force, F, that is constant.

$$m = W/g = (10^6\text{ N})/(10\text{ N/kg}) = 10^5\text{ kg}$$

10. Name three sources of a non-conservative force that (likely or not) stops the train.

Friction   Humans   Explosion (Rocket)

11. What is the acceleration (with units) of the train?

$$v^2 - v_0^2 = 2\mathbf{a}\ \mathbf{s};\quad \mathbf{a} = \frac{-v_0^2}{2\mathbf{s}} = \frac{-900\text{ m}^2/\text{s}^2}{+200\text{ m}} = 4.5\text{ m/s}^2$$

12. What is the value (with units) of the force F ?

$$F = ma = \left(10^5\text{ kg}\right)\left(4.5\text{ m/s}^2\right) = 4.5\times10^5\text{ N}$$

13. Is the force F an internal or an external force? External

14. Is the momentum of the train conserved? NO

15. What other momentum must be considered to show that the total momentum is conserved and what is its magnitude, and direction? Momentum of the Earth

train's momentum magnitude: $mv = (10^5\text{ kg})(30\text{ m/s}) = 3\times10^6\text{ kg m/s}$

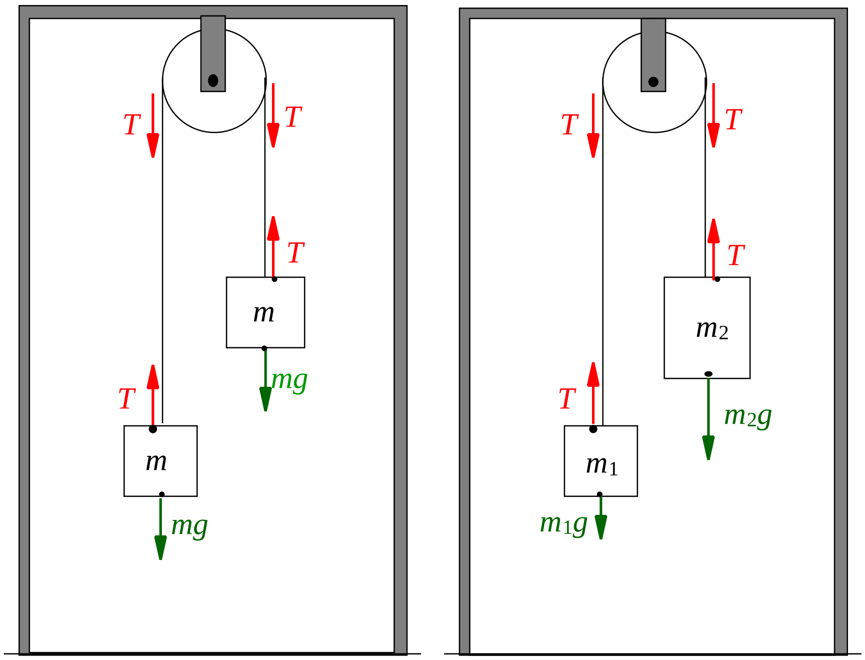
direction : negative (–)

16. To move as stated, a force must be applied to the train. To find its magnitude, F, use energy conservation, including the work done by that force. $F = 4.5\times10^5$ N

$$w_{NC} = \Delta KE$$
$$\mathbf{F}\ \mathbf{s} = \tfrac{1}{2}m(v^2 - v_0^2)$$
$$(-F)(+s) = -\tfrac{1}{2}mv_0^2$$
$$F = \frac{\frac{1}{2}mv_0^2}{s} = \frac{(5\times10^4\text{ kg})(900\text{ m}^2/\text{s}^2)}{100\text{ m}}$$
$$= 4.5\times10^5\text{ kg m/s}^2 = 4.5\times10^5\text{ N}$$

17. Use the change in momentum of the train and the value of F to determine the time it takes for the train to reach $v = 0$. 6.6 seconds

$$t = \frac{\Delta\mathbf{p}}{\mathbf{F}} = \frac{m\left(\mathbf{v} - \mathbf{v}_0\right)}{+F} = \frac{(10^5\text{ kg})\left(0 - (-30\text{ m/s})\right)}{+4.5\times10^5\text{ N}}$$
$$= \frac{(10^5\text{ kg})(30\text{m/s})}{4.5\times10^5\text{ N}} = 6.6\text{s}$$



Two masses are attached to a string that runs through the massless pulley as shown in the figure. Only gravity and the tension in the string act on the masses.

18. If the masses are equal, $m_1 = m_2 = m$, which statement below is true?

a) the tension in the string is *mg*.

b) the tension in the string is 2*mg*.

c) the tension in the string is zero.

d) the masses must be at rest.

e) the speed of the masses can be different.

19. If the masses shown at the right are not equal to each other, which statement below is true:

a) the speed of the masses cannot be zero.

b) the two masses cannot have the same speed.

c) the magnitude of the acceleration of the masses can be zero.

d) the two masses can never have the same magnitude of the acceleration.

e) the two masses must have the same speed, the same magnitude of the acceleration, and the same tension acting on them.