1. a) The distance between the axis of rotation and the line along which the force acts is the same on both sides of the lever; thus the force must be the same on both sides: F = 5.00 N

   b) On the right side the distance between the axis of rotation and the line along which the force acts is twice as large as on the left side; thus the force must be half on the right side: F = 5.00 N

   c) On the right side the magnitude of the force acting is a third of the force acting on the left side. Thus the lever arm on the right must be three times greater than the lever arm on the left: hole 6

   d) On the right side, the lever arm (distance between the axis of rotation and the line along which the force acts) is one quarter of the lever arm on the left side. Thus the force on the right side must be four times greater: F = 16.0 N

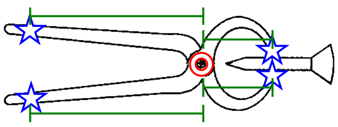
   e) The force pulling upwards turns the lever clockwise, while the force pulling down turns the lever counterclockwise. For equilibrium we need $F_{\text{clockwise}} \cdot r_{\text{clockwise}} = F_{\text{counterclockwise}} \cdot r_{\text{counterclockwise}}$

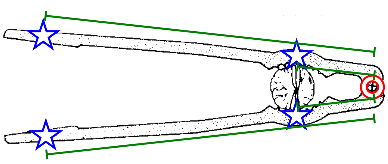
   Thus $F_{\text{clockwise}} = \dfrac{F_{\text{counterclockwise}} \cdot r_{\text{counterclockwise}}}{r_{\text{clockwise}}} = \dfrac{10.0\text{ N} \cdot 0.30\text{ m}}{0.50\text{ m}} = \underline{6.00\text{ N}}$

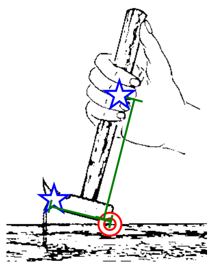
   f) The force pulling upwards turns the lever clockwise, while the force pulling down turns the lever counterclockwise. For equilibrium we need $F_{\text{clockwise}} \cdot r_{\text{clockwise}} = F_{\text{counterclockwise}} \cdot r_{\text{counterclockwise}}$

   Thus $F_{\text{clockwise}} = \dfrac{F_{\text{counterclockwise}} \cdot r_{\text{counterclockwise}}}{r_{\text{clockwise}}} = \dfrac{1.00\text{ N} \cdot 0.60\text{ m}}{0.20\text{ m}} = \underline{3.00\text{ N}}$

2. axis of rotation: point where the force is applied: lever arm:

a) 

b) 

c) 

3. a) The piece of mass is moved along the lever arm until the lever is balanced. The mass of the object to be weighed can be calculated from the given mass of the piece of mass and its distance from the pivot (axis of rotation). A scale on the lever arm shows the mass of the object to be weighed.

   b) For equilibrium we have $M_{\text{clockwise}} = M_{\text{counterclockwise}}$

   which means $F_{\text{clockwise}} \cdot r_{\text{clockwise}} = F_{\text{counterclockwise}} \cdot r_{\text{counterclockwise}}$

   We use $F_{\text{clockwise}} = F_{\text{G(potatoes)}} = m_{\text{potatoes}} \cdot g$ and $F_{\text{counterclockwise}} = F_{\text{G(piece of mass)}} = m_{\text{piece of mass}} \cdot g$

   and substitute $m_{\text{potatoes}} \cdot g \cdot r_{\text{clockwise}} = m_{\text{piece of mass}} \cdot g \cdot r_{\text{counterclockwise}}$

   Thus $m_{\text{potatoes}} = \dfrac{m_{\text{piece of mass}} \cdot r_{\text{counterclockwise}}}{r_{\text{clockwise}}} = \dfrac{2.00\text{ kg} \cdot 0.60\text{ m}}{0.10\text{ m}} = \underline{12.0\text{ kg}}$

4. a) $M = r \cdot F = 0.18\ \text{m} \cdot 500\ \text{N} = \underline{\underline{90\ \text{Nm}}}$

b) $F = \dfrac{M}{r} = \dfrac{90\ \text{Nm}}{0.09\ \text{m}} = \underline{\underline{1000\ \text{N}}}$

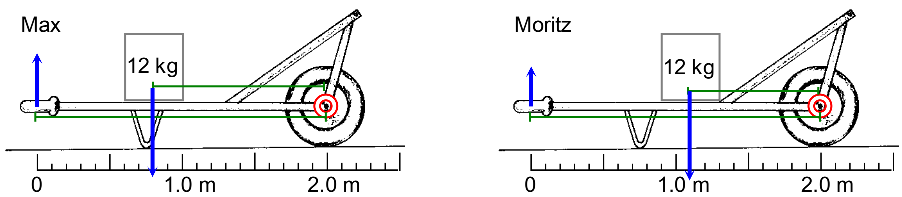
c) same: $\underline{\underline{1'000\ \text{N}}}$

d) $M = r \cdot F = 0.045\ \text{m} \cdot 1'000\ \text{N} = \underline{\underline{45\ \text{Nm}}}$

e) $F = \dfrac{M}{r} = \dfrac{45\ \text{Nm}}{0.36\ \text{m}} = \underline{\underline{125\ \text{N}}}$

5. a) Moritz; the box is closer to the pivot and therefore the torque (moment of force) is smaller.

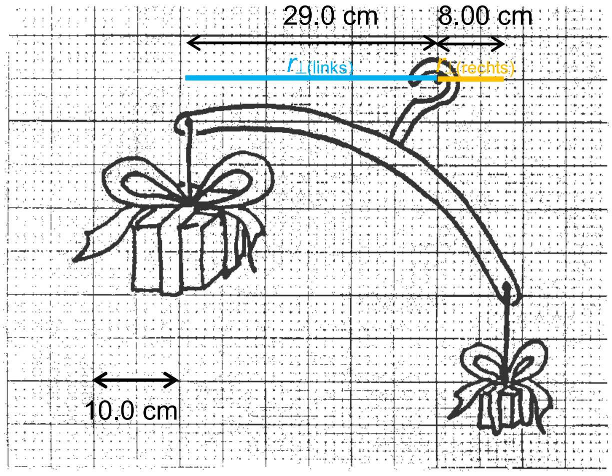
b) pivot: force: lever arm:



c) The weight of the box produces a counterclockwise rotation:
$M_{\text{counterclockwise}} = F_{G(\text{box})} \cdot r_{\text{box}} = m_{\text{box}} \cdot g \cdot r_{\text{box}}$
Max: $M_{\text{counterclockwise}} = m_{\text{box}} \cdot g \cdot r_{\text{box}} = 12\ \text{kg} \cdot 9.81\ \dfrac{\text{N}}{\text{kg}} \cdot 1.20\ \text{m} = \underline{\underline{141\ \text{Nm}}}$
Moritz: $M_{\text{counterclockwise}} = m_{\text{box}} \cdot g \cdot r_{\text{box}} = 12\ \text{kg} \cdot 9.81\ \dfrac{\text{N}}{\text{kg}} \cdot 0.90\ \text{m} = \underline{\underline{106\ \text{Nm}}}$

d) For equilibrium, Max and Moritz need to apply a clockwise torque of the same magnitude (by lifting the wheelbarrow at its handle):
$M_{\text{counterclockwise}} = M_{\text{clockwise}}$
Max: $F_{\text{hand}} = \dfrac{M_{\text{counterclockwise}}}{r_{\text{hand}}} = \dfrac{141\ \text{Nm}}{2.00\ \text{m}} = \underline{\underline{71\ \text{N}}}$
Moritz: $F_{\text{hand}} = \dfrac{M_{\text{counterclockwise}}}{r_{\text{hand}}} = \dfrac{106\ \text{Nm}}{2.00\ \text{m}} = \underline{\underline{53å\ \text{N}}}$

6. a)



b) $M = r_{\perp(\text{left})} \cdot F_{\text{left}} = r_{\perp(\text{right})} \cdot F_{\text{right}}$

$$F_{\text{left}} = \frac{r_{\perp(\text{right})} \cdot F_{\text{right}}}{r_{\perp(\text{left})}} = \frac{8.00\text{ cm} \cdot 7.25\text{ N}}{29.0\text{ cm}} = \underline{\underline{2.00\text{ N}}}$$