Aufgabe 1: The Martian: Solution *(4 points)*

i. (2 pts) As the center of mass of the astronaut's body reaches a maximal height of $h = 50\,\text{cm}$, it has to have a kinetic energy of

$$E_{\text{kin}} = mgh \tag{1}$$

at take-off. This energy is built up by the force of the legs during the jumping motion, during which the astronaut lifts his the center of mass by $s = 40\,\text{cm}$. Let F_{legs} be the mean force exerted on the ground. Then we can write

$$E_{\text{kin}} = \int \vec{F} \cdot d\vec{s} = (-mg + F_{\text{legs}}) \cdot s \tag{2}$$

$$\Rightarrow F_{\text{legs}} = mg\frac{h+s}{s} = 70\,\text{kg} \cdot 9.81\,\text{m/s}^2 \cdot \left(1 + \frac{0.5\,\text{m}}{0.4\,\text{m}}\right) = 1.5\,\text{kN}$$

Grading: *0.5 points* for the idea to use conservation of energy like in (1). *0.5 points* for (2), *0.5 points* for the algebraic expression of h, *0.5 points* for the numerical result of h with exactly 2 significant digits.

ii. (1.5 pts) Similarly, we compute

$$mg_{\text{mars}}h = (F_{\text{legs}} - mg_{\text{mars}}) \cdot s \tag{3}$$

$$\Rightarrow h = \frac{s}{m}\left(\frac{F_{\text{legs}}}{g_{\text{mars}}} - m\right) = \frac{0.4\,\text{m}}{170\,\text{kg}}\left(\frac{1.5\,\text{kN}}{9.81\,\text{m/s}^2 \cdot 0.38} - 170\,\text{kg}\right) = 58\,\text{cm}$$

Grading: *0.5 points* for the idea to use (1) and (2) here, like in (3). *0.5 points* for the algebraic expression of h, *0.5 points* for the numerical result of h with exactly 2 significant digits.

iii. (0.5 pts) And again, with $m = 70\,\text{kg}$:

$$h = \frac{s}{m}\left(\frac{F_{\text{legs}}}{g_{\text{mars}}} - m\right) = \frac{0.4\,\text{m}}{70\,\text{kg}}\left(\frac{1.5\,\text{kN}}{9.81\,\text{m/s}^2 \cdot 0.38} - 70\,\text{kg}\right) = 2.0\,\text{m}$$

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Grading: *0.5 points* for the numerical result of h with exactly 2 significant digits.