

4. We estimate his mass in the neighborhood of 70 kg and compute the upward force F of the water from Newton's second law.

$$F - mg = ma$$

where we have chosen $+y$ upward, so that $a > 0$ (the acceleration is upward since it represents a deceleration of his downward motion through the water). His speed when he arrives at the surface of the water is found either from Eq. 2-16 or from energy conservation:

$$v = \sqrt{2gh}$$

where $h = 12$ m, and since the deceleration a reduces the speed to zero over a distance $d = 0.30$ m we also obtain $v = \sqrt{2ad}$. We use these observations in the following.

- (a) Equating our two expressions for v leads to $a = gh/d$. Our force equation, then, leads to

$$F = mg + m \left(g \frac{h}{d} \right) = mg \left(1 + \frac{h}{d} \right)$$

which yields $F \approx 2.8 \times 10^4$ kg. Since we are not at all certain of his mass, we express this as a guessed-at range (in kN) $25 < F < 30$.

- (b) Since $F \gg mg$, the impulse \vec{J} due to the net force (while he is in contact with the water) is overwhelmingly caused by the upward force of the water: $\int F dt = \vec{J}$ to a good approximation. Thus, by Eq. 10-2,

$$\int F dt = \vec{p}_f - \vec{p}_i = 0 - m \left(-\sqrt{2gh} \right)$$

(the minus sign with the initial velocity is due to the fact that downward is the negative direction) which yields $(70)\sqrt{2(9.8)(12)} = 1.1 \times 10^3$ kg·m/s. Expressing this as a range (in kN·s) we estimate $1.0 < \int F dt < 1.2$.