$$\vec{F}_{net} = \frac{d\vec{p}}{dt} \Rightarrow d\vec{p} = \vec{F}\,dt \Rightarrow \int_{\vec{p}_i}^{\vec{p}_f} d\vec{p} = \int_{t_i}^{t_f} \vec{F}\,dt \Rightarrow \Delta\vec{p} = \vec{J}$$

sec. 9-6 Collision and Impulse

•23 Until his seventies, Henri LaMothe (Fig. 9-48) excited audiences by belly-flopping from a height of 12 m into 30 cm of water. Assuming that he stops just as he reaches the bottom of the water and estimating his mass, find the magnitude of the impulse on him from the water.



Fig. 9-48 Problem 23. Belly-flopping into 30 cm of water. *(George Long/ Sports Illustrated/©Time, Inc.)*

$$\vec{J} = \int_{t_i}^{t_f} \vec{F}\,dt \equiv \vec{F}_{AVG}\,\Delta t$$

where Δt = time interval during which the Impulsive Force acts. We need Henri's speed when he hits the water, v_0.

$W_{net\ sys}^{ext} = \Delta E_{sys}^{tot}$ system = Henri + Earth

$\Rightarrow \Delta E_{mech}^{tot} = 0 = \Delta K = -\Delta U$

$\Rightarrow \frac{1}{2}mv_0^2 - 0 = -mg\Delta y$ where i = jump f = hit water. h = height of jump, d = depth of water.

$\Rightarrow \frac{1}{2}mv_0^2 = -mg(-(h-d))$

$\Rightarrow v_0 = \sqrt{2g(h-d)} \approx \sqrt{2gh}$

Impulse $= \vec{J} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i =$

$= 0 - mv_0\,\hat{down} = mv_0\,\hat{up}$

The impulsive Force acts for a time Δt during which the net Force acting on Henri is

$\vec{F}_{net} = \vec{F}_{H,w} + m\vec{g} \approx \vec{F}_{H,w}$ = Impulse Force

$\Rightarrow \vec{F}_{H,w} = \frac{\Delta\vec{p}}{\Delta t}$ we need to find Henri's Last Δt. We assume constant acceleration during the Impulse. The AVERAGE VELOCITY would be $\langle v \rangle = \frac{\vec{v}_i + \vec{v}_f}{2} = \frac{-v_0\hat{y} - 0}{2} = \frac{-v_0}{2}\hat{y} = \frac{-\sqrt{2g(h-d)}}{2}\hat{y}$

AVERAGE VELOCITY = ALSO $= \frac{\Delta\vec{r}}{\Delta t} = \frac{-d\hat{y}}{\Delta t} \Rightarrow \Delta t = \frac{2d}{v_0}$ HENRI'S LAST Δt

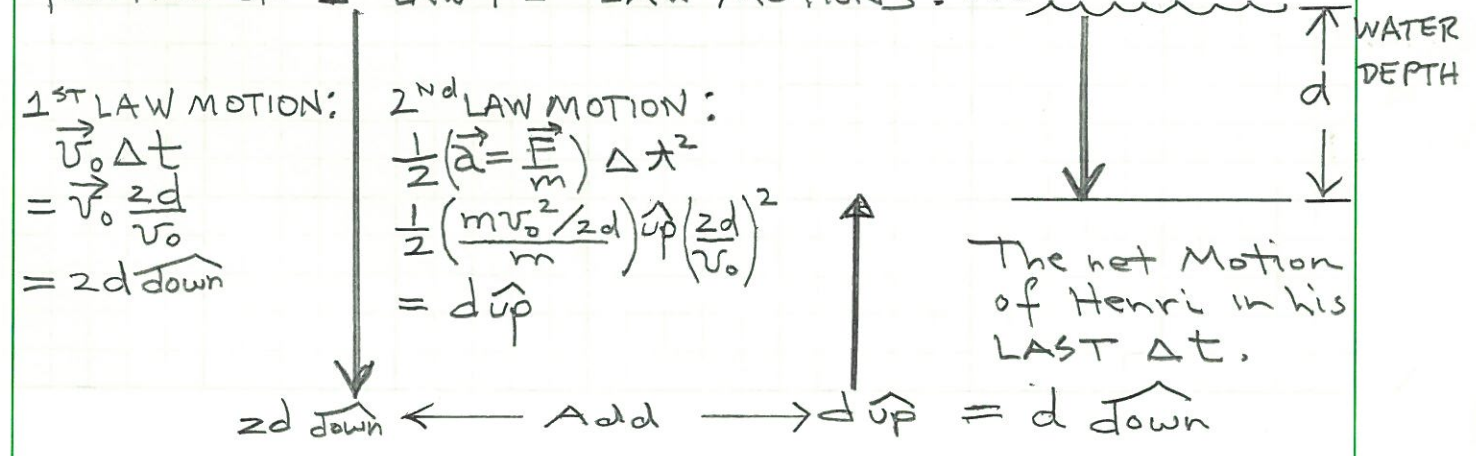
$\Rightarrow \vec{F}_{H,w} = \frac{\Delta\vec{p}}{\Delta t} = \frac{mv_0\hat{up}}{2d/v_0} = mv_0^2/2d\,\hat{up} = m[2g(h-d)]/2d\,\hat{up} = \frac{mg(h-d)}{d}\hat{up}$

$= 80\text{kg}\,9.8\frac{m}{s^2}(12-0.3)\text{m}/0.3\text{m} = 30{,}600\text{N}\,\hat{up}$. $\vec{J} = \Delta\vec{p} = (mv_0 = 80\sqrt{2(9.8)(12-0.3)})\hat{up}$

$= 80\text{kg}\,15.1\frac{m}{s}\hat{up} = 1{,}210\frac{kg\,m}{s}\hat{up}$. $\Delta t = 2d/v_0 = 2(0.3\text{m})/15.1\,m/s = 0.0397\text{s}$

HENRI'S $\vec{a}$ in the LAST $\Delta t = \vec{a} = \vec{F}_{H,w}/m = 30{,}600\text{N}/80\text{kg} = 383\,m/s^2 = 39g_s\,\hat{up}$

NEWTON THOUGHT of motion in a small Δt as a LINEAR SUPERPOSITION OF 1ST LAW + 2ND LAW MOTIONS: ...



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