Chapter 12 PART C: Momentum and Impulse

KINESIOLOGY

Scientific Basis of Human Motion, 11th edition

Hamilton, Weimar & Luttgens

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Objectives

1. Momentum
2. Impulse

Conservation of Momentum

$$(m_1 v_{1final} - m_1 v_{1initial}) = (m_2 v_{2final} - m_2 v_{2initial})$$

m_1= mass of bat

v_1 = velocity of bat

m_2= mass of ball

v_2 = velocity ball

Above ignores:

1. "Trampoline effect" of bat
2. Stiffness and mass of batter



Internal forces and momentum transfer for throwing a ball

- Force from legs transferred to trunk
- Further muscular force increases momentum and is transferred to upper arm
  - Mainly as an increase velocity because mass is smaller
- Sequential transfer of momentum continues with mass decreasing and velocity increasing
- Finally momentum is transferred to thrown ball


Phillies

Impulse $Ft = m(v_f - v_i)$

The product of force and the time it is applied

$F = ma$

- Substitute $(v_f - v_i) / t$ for a:

$F = m (v_f - v_i) / t$

- Multiply both sides by time:

$Ft = m (v_f - v_i)$

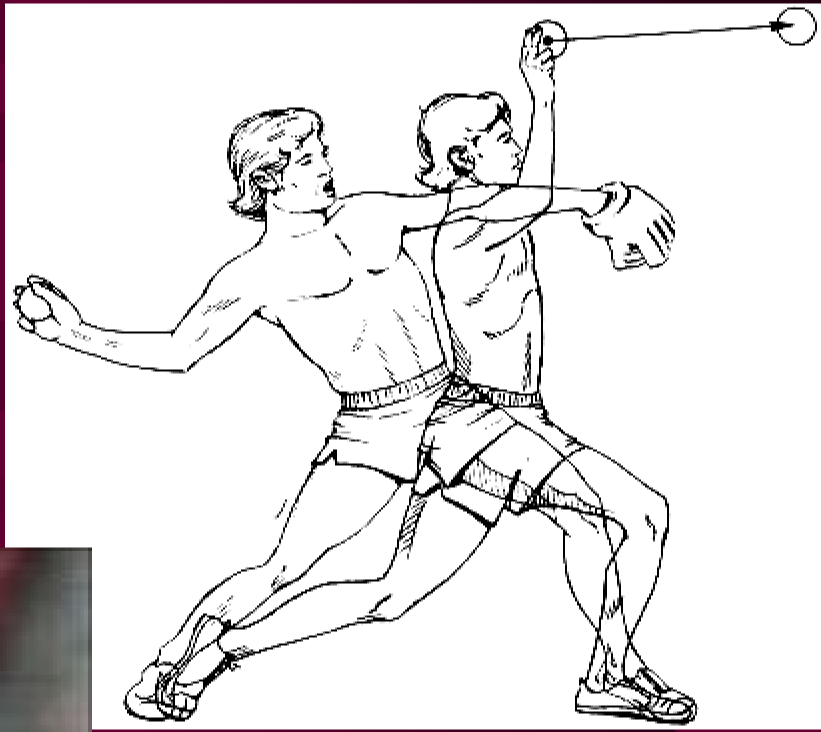

Fig 12.12


Phillies


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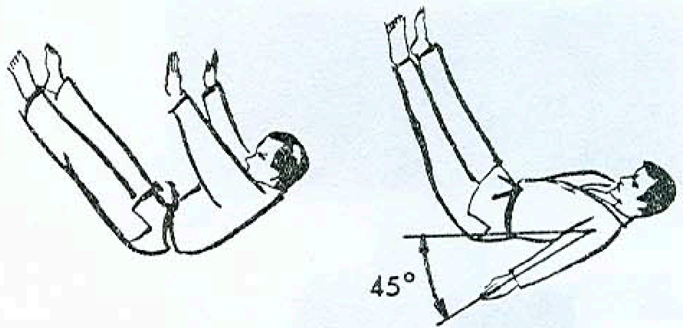
Impulse and Momentum

$$Ft = mv_f - mv_i$$

- Any change in momentum is equal to the impulse that produces it
- Force applied in direction of motion will increase momentum
- Force applied opposite to direction of motion will decrease momentum; for example, how hard will UKE hit the ground?



HE SECRETS OF

JUDO

A Text for Instructors and Students

TUTTLE MARTIAL A

WITH NOTES BY
Dr. J. WUNDERLICH

Ukemi: the art of falling

In judo the method of falling is an art in itself. Mastery of *ukemi*, or the art of falling, is essential not only for the execution of free and quick movements but also for the prevention of injury when you are thrown. Thus *ukemi* is the first technique for you to learn and master. First let us see how long it takes for a falling body to strike the mat.

When a body falling from a position at rest drops to the ground by means of gravitation, it travels 980 centimeters in the first second, 1,960 in the next second, and 2,940 in the third second. You will notice that an acceleration of 980 centimeters per second is produced uniformly every second during the fall. Since the body drops with a uniform acceleration, the average velocity is half the sum of the initial velocity and the final velocity. Average velocity can thus be expressed in the following equations, in which Vav stands for average velocity, Vo for initial velocity, Vt for final velocity, t for time, and A for acceleration:

1. $Vav = \dfrac{Vt + Vo}{2}$

and since the acceleration is uniform,

2. $A = \dfrac{Vt - Vo}{t}$

which results in

3. $Vt = Vo + At$

and, when Vo equals zero,

NOTE: ALL Vt SHOULD BE WRITTEN AS V_t

4. $Vt = At$

Now, substituting in Equation 1 the value of Vt from Equation 3:

5. $Vav = \frac{Vo + (Vo + At)}{2}$

$= Vo + \frac{1}{2}At$

Then, to find the total space S traveled in time t, we multiply the average velocity Vav by t to obtain the following:

6. $S = Vavt$

$= Vot + \frac{1}{2}At^2$

By making use of Equation 6, let us find the force produced when a man weighing 75 kilograms hits the ground from a height of 1.5 meters. (See Figure 66.) If $S = \frac{1}{2}At^2$, then

$1.5\text{ m} = \frac{1}{2} \times 980\text{ cm/sec}^2 \times t^2$

$t^2 = \frac{150\text{ cm}}{490\text{ cm/sec}^2}$

$t = \frac{\sqrt{15}}{7}\text{ sec}$

$t = 0.5\text{ sec}$

Now, to find the velocity in 0.5 seconds after the man starts to fall:

$Vt = At$

$= 980\text{ cm} \times 0.5\text{ sec}$

$= 490\text{ cm/sec}$

If we take the time that is required to stop the body as a unit, the resisting force of the mat is found as follows:

mv = resisting force of mat

$= 75\text{ kg} \times 490\text{ cm/sec}$

$= 36{,}750\text{ kgcm/sec}$

OR "+"

$S = \vec{V}_0 t + \frac{1}{2}\vec{A}t^2$

FOR THIS EXAMPLE, $\vec{V}_0 = \emptyset$, SO:

$S = \emptyset + \frac{1}{2}\vec{A}t^2$

$t^2 = 2S/\vec{A}$

$t = \sqrt{2S/\vec{A}} = \sqrt{2(150\text{cm})/(980\frac{\text{cm}}{\text{sec}^2})}$

$\vec{V}_t = \vec{A} * t$ (i.e.) DIMENSIONAL ANALYSIS

$= \left(980\frac{\text{cm}}{\text{sec}^2}\right) * (0.5\text{ sec})$

$\vec{V}_t = 490\frac{\text{cm}}{\text{sec}}$

cm/sec²

NOW, USING "IMPULSE EQUATION" (SEE P. 305 OF KINESIOLOGY TEXT):

$\vec{F}t = m(\vec{V}_{FINAL} - \vec{V}_{INITIAL})$

AND SINCE $\vec{V}_{FINAL} = \emptyset$

AND $t = 1$ (i.e., ASSUMED HERE AS A "UNIT" TIME);

$\vec{F} * (1) = m(\emptyset - \vec{V}_{INITIAL})$

$\vec{F} = -m\vec{V}_{INITIAL}$

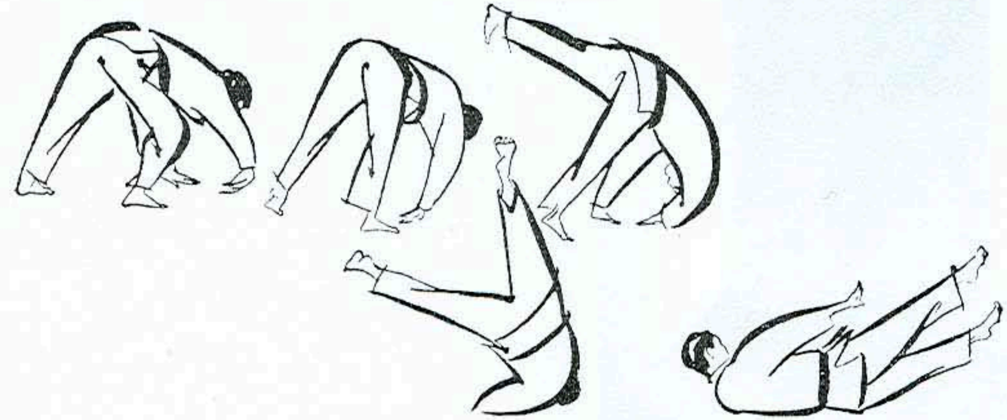
AND $\vec{V}_{INITIAL} = \vec{V}_t$ (i.e., IMPULSE STARTS AFTER BODY AT END OF FALL);

$\vec{F} = -m\vec{V}_t = -(75\text{ kg} * 490\frac{\text{cm}}{\text{sec}^2}) = -36{,}750\frac{\text{kgcm}}{\text{sec}}$ (AND "−" MEANS $\vec{F}$ IS POINTING UP)

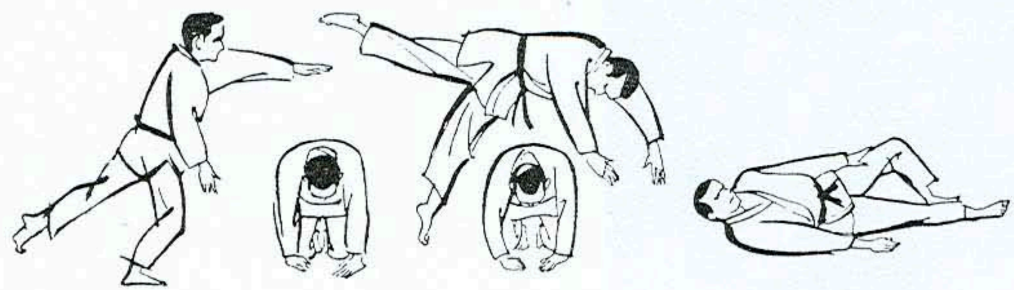
UKEMI
(“Break Fall”)

including

ZEMPO KAITEN
(“Forward Rolling”) →



72. Technique of right forward roll.



73. Practice in jumping over an obstacle.