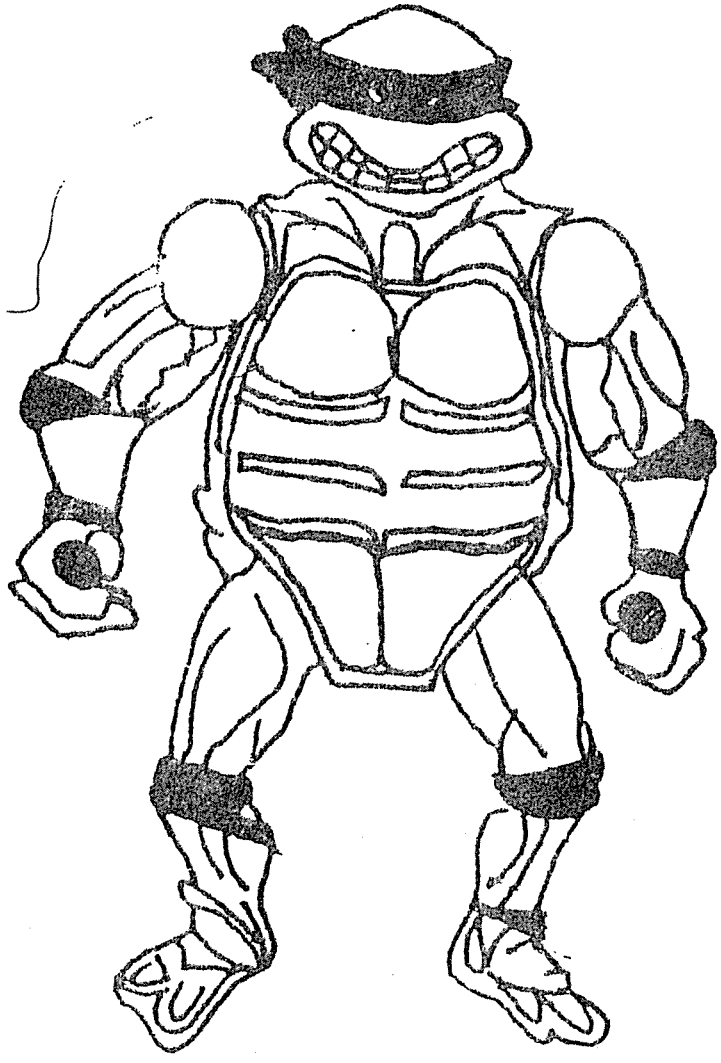
SIR ISAAC TURTLE'S



GUIDE TO

SKIING PHYSICS

BY
GUY BIEN
Jan 27, 1990

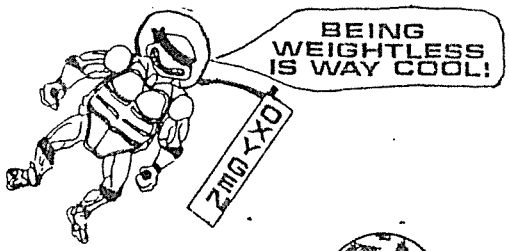
DEFINITIONS OF TERMS FOR PHYSIC TURTLE MASTERS

A. Properties of a turtle

1. Mass- The amount of material in a turtle.

2. Weight- A gravity induced force. Not to be confused with mas

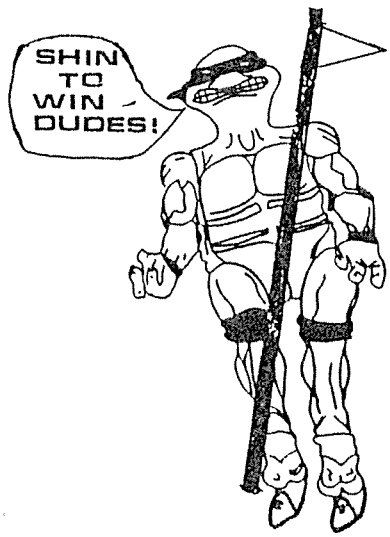
Example: Isaac in space is weightless, but Isaac on earth is 250 pounds.

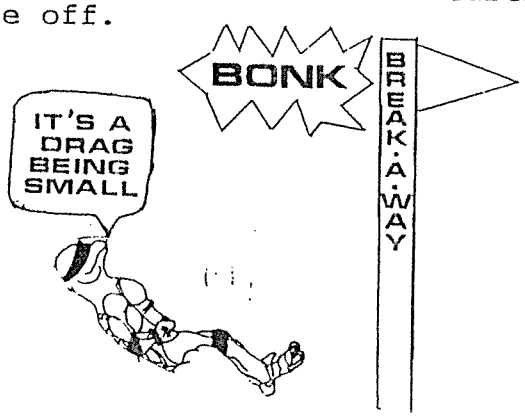


Note: For turtles that ski on Earth, the terms are interchangeable.

3. Inertia- The property of a turtle to resist forces.

Example- A large turtle will move through a rapid gate without slowing down because he has a large inertia, whereas a small turtle will bounce off.



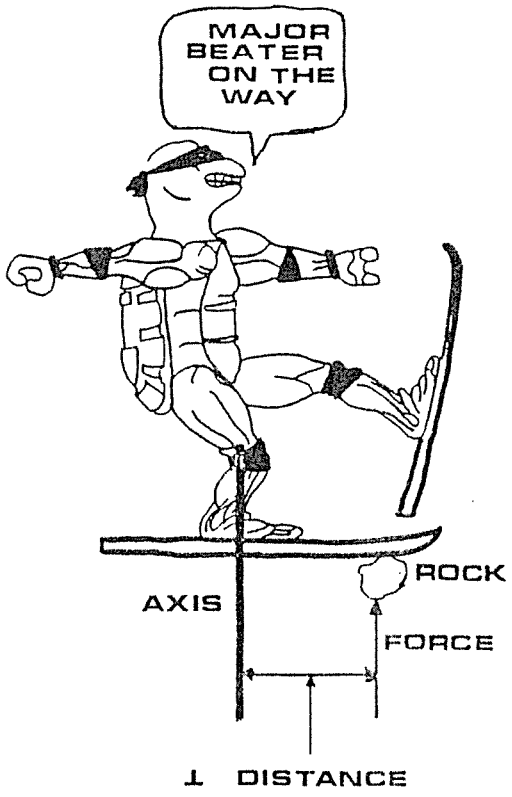


4. Center of Gravity- The balance point of an object. The place where all of the mass appears to be concentrated. Marked by ◔.

B. Actions experienced by a turtle.

1. Force- A push or a pull that will change the direction of a turtle.

2. Torque- A twisting force about an axis. Can be measured by the force times the perpendicular distance from the axis.



3. Pressure- The amount of force per unit area.

   Example: 100 lbs per square inch. Thus in a skills approch, Pressure control is a controlling of the forces in a turn.

C. How to measure a turtles motion.

1. Scaler- A unit of measure, a number. e.g. 55mph or 10lbs.

2. Vector- Force with direction. e.g. 55mph, north.

3. Speed- A measurement of distance per unit of time, a scaler. e.g. Miles per hour or meters per second.

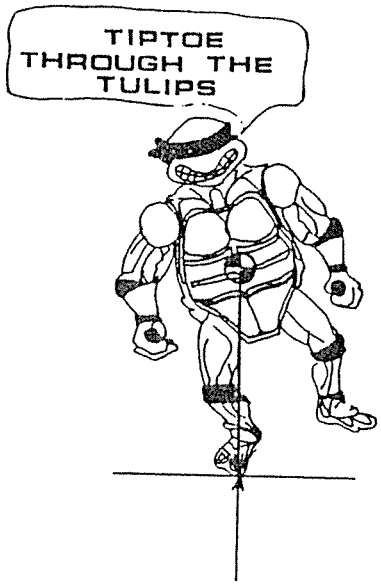
4. Velocity- Speed with direction, a vector. 100mph downhill.

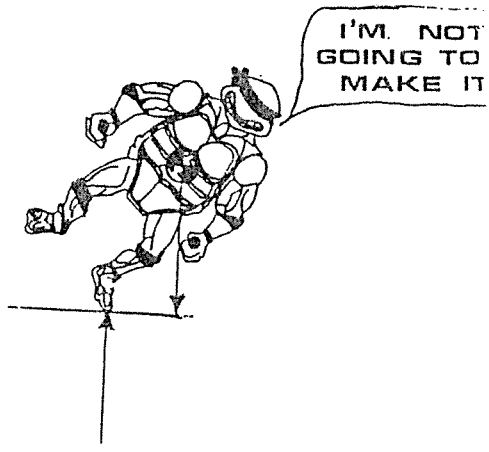
5. Acceleration- How fast velocity is changing, a vector.

6. Momentum- Mass times velocity. Since velocity is a vector and mass is a scaler, momentum must be a vector.

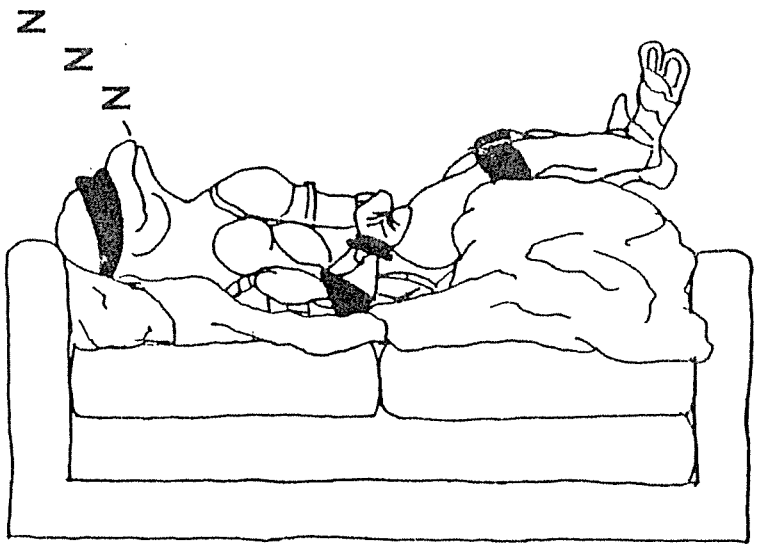
7. Balance- The act of maintaining equilibrium.

8. Equilibrium- When the sum of all forces and torques equal ze



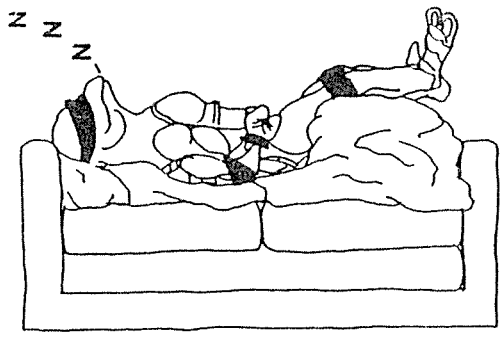


9. Moment of Inertia- A turtles resistance to a rotational force.

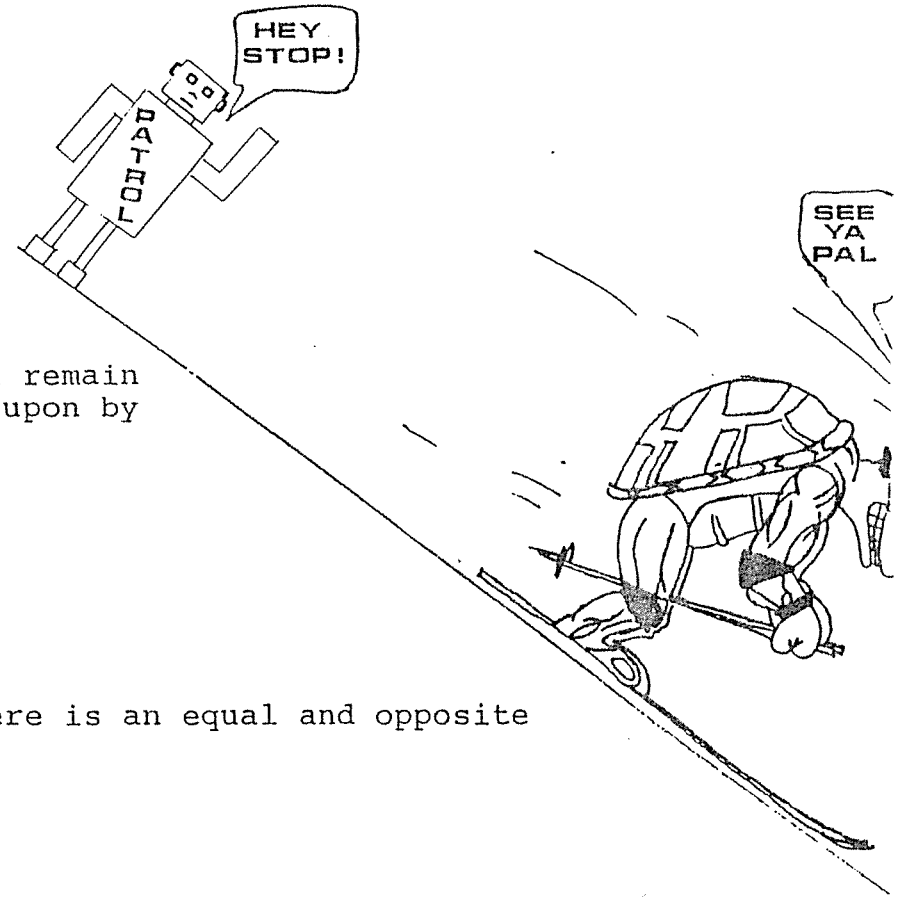


NEWTON'S LAWS OF MOTION

*A partial list

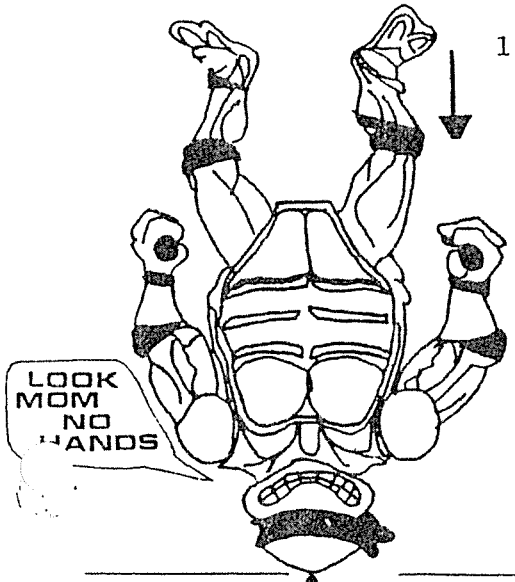


1. An object at rest tends to remain at rest or



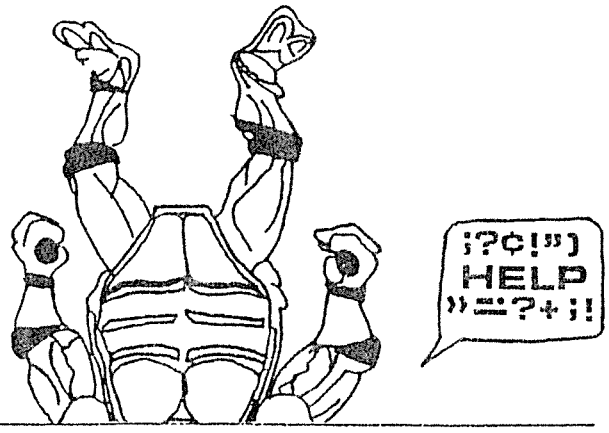
an object in motion will remain in motion, unless acted upon by a force.

2. For every action there is an equal and opposite reaction.



100 lbs exerted by Isaac.

100 lbs exerted by the snow.



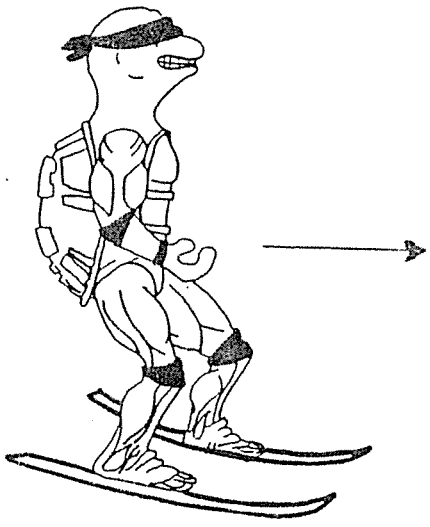
What happens when no force is exerted.

TYPES OF FORCES IN TURTLE SKIING

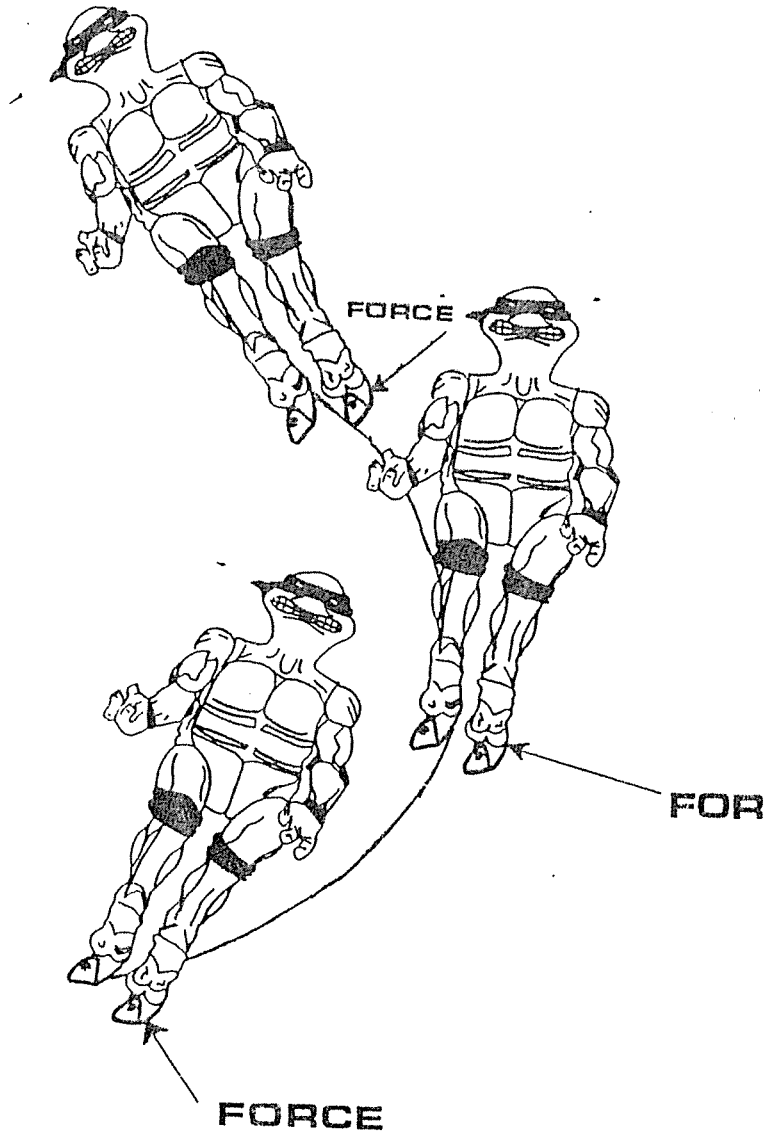
1. Centripetal
2. Centrifugal
3. Gravity
4. Friction
5. Muscle Action

DIRECTION OF THE FORCES

1. Centripetal- Recall: All turtles will travel in a straight line unless acted upon by a force.

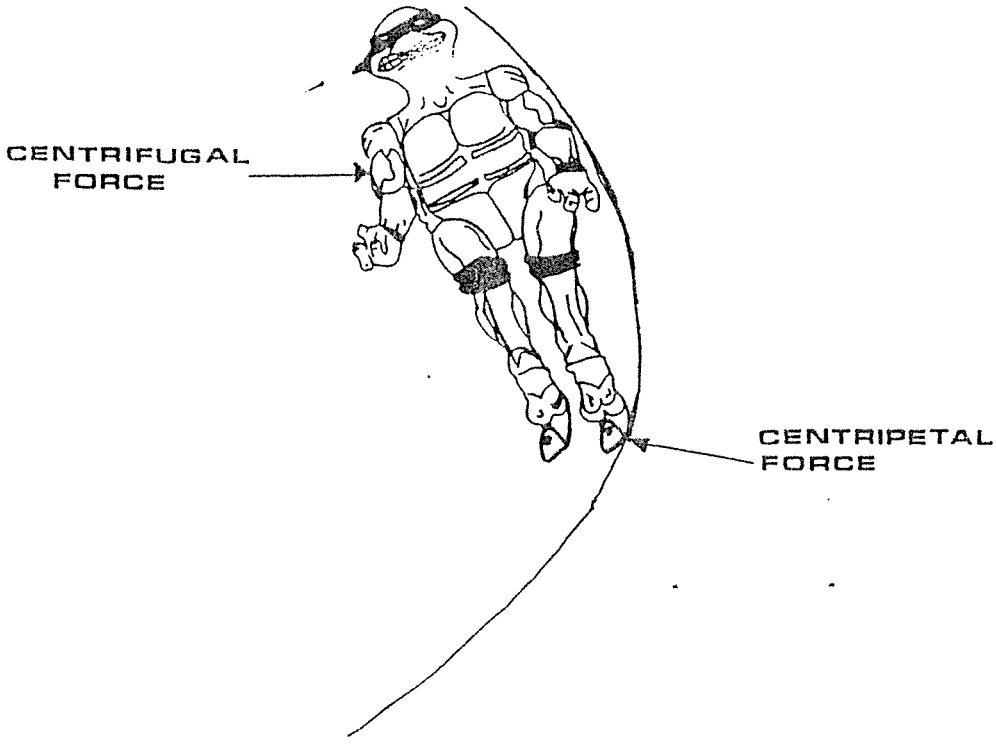


NO FORCE



Centripetal force acts toward the center in order to create a turn.

2. Centrifugal- Recall: Inertia is the resistance to change therefore the pull you feel to the outside of a turn is the resistance to change from your body. We call it centrifugal force.

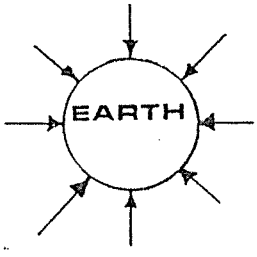


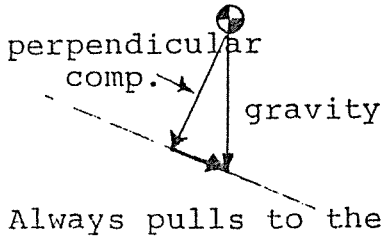
Centrifugal force operates to the outside of the turn and is equal and opposite to centripetal force.

*For the true master physic turtles the equation for both forces is

$$\frac{\text{MASS} \times \text{VELOCITY}^2}{\text{RADIUS}} \quad \text{OR} \quad \frac{MV^2}{R}$$

An analogy might be a boy swinging a bucket of water in a circle. The force pushing the water in the bucket is centrifugal, the force pushing the bucket to the water is centripetal.





3. Gravity- Always pulls to the center of the earth. It can be broken down into two components, perpendicular to the ground and parallel. See Diagram above.

3. Gravity (con't)

The parallel component is the speed component. The steeper the hill the bigger the parallel component, the faster the speed

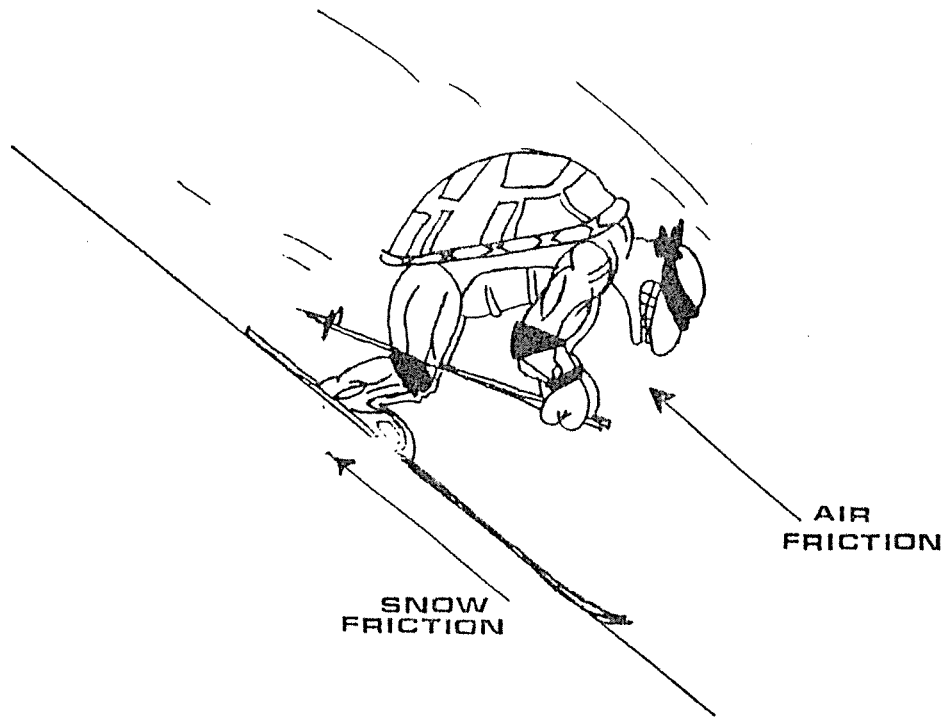
The perpendicular component is the friction component. The bigger the component the more friction between the ski and the snow.

*See forces in a straight run for pictures and clarification.

4. Friction- Always operates opposite the direction of motion.

2 Types A) Snow Friction- Fairly constant for a given slope and snow type.

B) Air Friction- Increases exponentially as the velocit of the turtle increases.



5. Muscle Actions.

A. Lower leg steering- Twisting of the leg creates a torque on the skis. Example- Braquage

B. Anticipation Release- A twisting of the torso. Using the mid-section muscles as a spring. When released the muscles realign and create a torque on the skis.

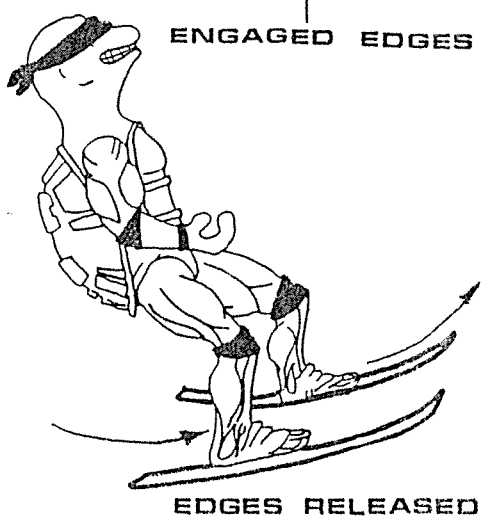
C. Rotation- A.K.A. Blocked Rotation.

A two step process based on the conservation of angular Momentum.

Part One: Angular momentum is put into the system by using the muscles of the upper body and turning it in the direction of the new turn while the edges are engaged.

ENGAGED EDGES

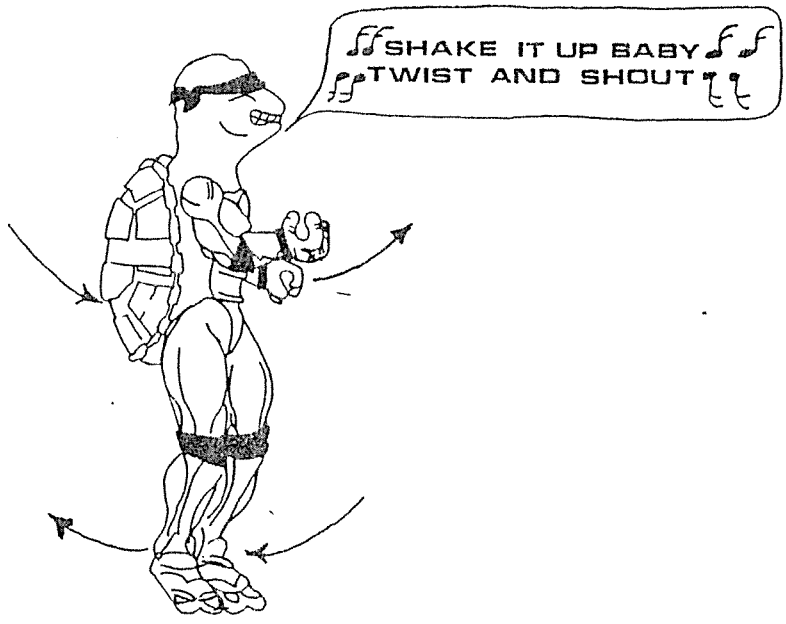
Part Two: When the upper body rotation is stopped or blocked, then the edges are released. The angular momentum created in the upper body is transferred to the lower body causing a torque on the skis and a turn is started.



EDGES RELEASED

D. Counter Rotation- A.K.A. The Bar Stool Effect.

A one step process using the conservation of angular momentum. First the skis must be flat. The upper body is rotated in one direction and the lower body rotates in the opposite direction simultaneously. This maintains the angular momentum of zero.



Large Moment of Inertia

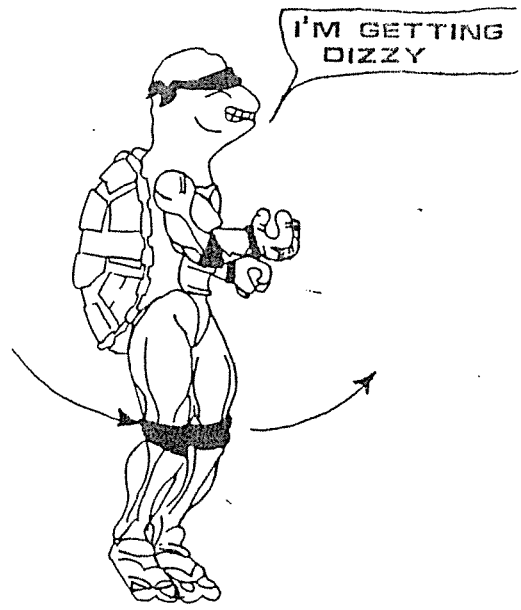
Isaac spinning at 30 rpm with arms outstretched. Moment of inertia is 100

Angular Momentum

$A = Inertia_b$ times rpm_b

$A = 100 \times 30$

$A = 3000$



Small Moment of Inertia

Isaac spinning again at 30 rpm, but the moment of inertia is only 50. Angular momentum must be conserved, so it still is 3000. Thus the rpm's must change.

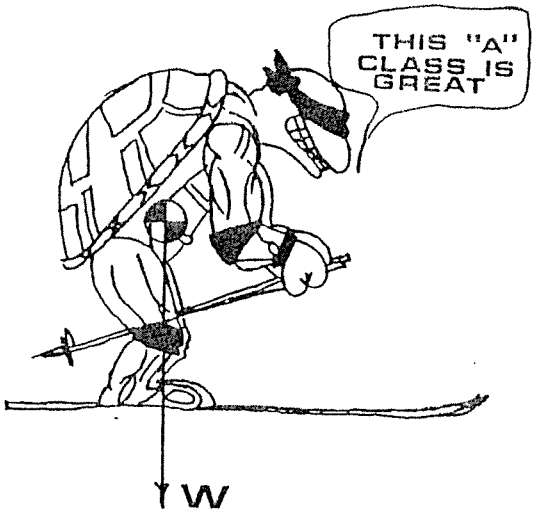
$A = Inertia_a$ times rpm_a

$3000 = 50 \times rpm_a$

$rpm_a = 60$

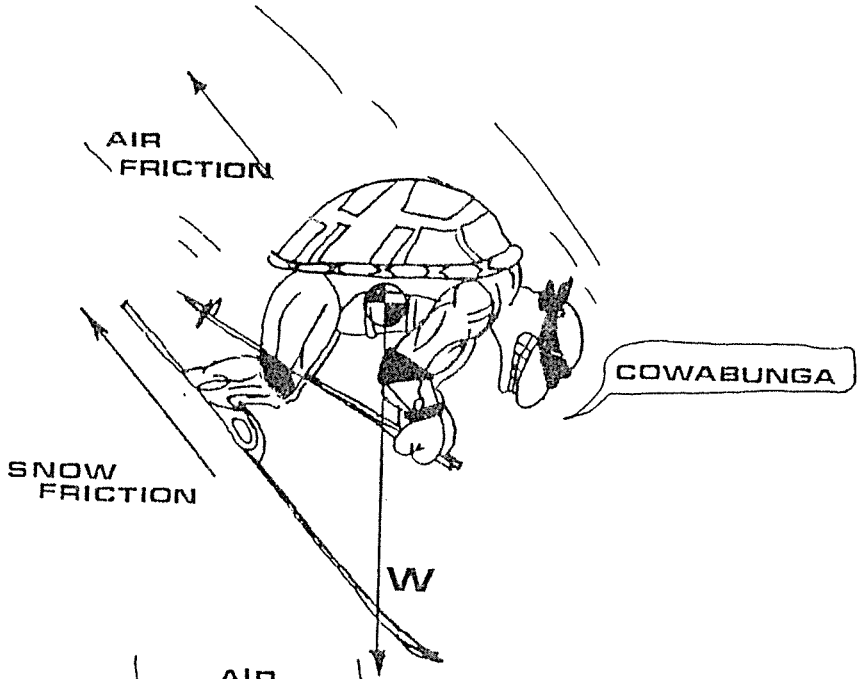
Once angular momentum is in the system it is conserved. It may be transferred from one place to another such as from the upper body to the lower body.

FORCES IN A STRAIGHT RUN



No force making Isaac move. Weight pulls straight down. Snow friction is at a maximum because of the weight pulling straight down.

No air friction because Isaac is not moving.



Gravity pulls both against the snow and down the hill.

There is snow friction but less than above.

Since Isaac is moving there is a friction.

Gravity pulls directly downhill, thus there is no snow friction. Isaac is free falling.

Isaac is moving very fast so there is a greater amount of air friction and is directly proportional to the speed.