Year 12

Physical Education Studies

Biomechanics

Newton’s 2nd Law of Motion

* “The rate of change of acceleration to a body is proportional to the force applied to it, and inversely proportional to the mass of the object.”
* F=m\*a
* E.g. given that both sprinters exert the same amount of acceleration, the sprinter that weighs more will travel faster than the lighter athlete

Conversation of Linear Momentum

* The total momentum of two objects before and after impact are equal
* Occurs where a perfectly elastic collision takes place

Newton’s Third Law

* For every action there is an equal or opposite reaction
* Eg. the force exerted by a backstroker pushing into the wall at the beginning of the race will push the backstroker in the opposite direction with the same amount of force

Impulse-Momentum relationship

* The longer the force is applied, the greater the impulse
* The shorter the force is applied, the shorter the impulse

Impulse and Sport

* Increasing momentum
	+ Eg. hockey
		- Strong hit (lots of force), small period of time = increase
		- Long hit (less force), long period of time = increase
* Decreasing momentum
	+ Eg. catching a ball
		- Increase in time to reduce peak force therefore decreasing momentum

Coefficient of Restitution

* COR measures the elasticity of the collision between an object and given surface
* COR of 1 = perfectly elastic meaning that when dropped, the object returns to that height
* COR of 0 = perfectly inelastic meaning that when dropped, the object does not bounce
* Measured by the square root of the height bounced over the height dropped

Factors affecting COR

* Equipment and Materials
* Temperature of the ball

Forces that create Angular Rotation

* Angular rotation is caused by the application of an eccentric force
* When only 1 eccentric force is applied to the object, both linear and angular motion occur
* To increase angular rotation one can either
	+ Increase the amount of force applied
	+ Increase the distance from the acis by which the force is applied
* Force couples
	+ Two equal forces act on opposite sides of the axis

Conversation of Angular Momentum

* Means that a spinning body will continue spinning indefinitely unless an external force acts on it
* Angular momentum remains constant even if angular velocity and moment of inertia fluctuate and change

Levers

* 1st class
	+ axis in the middle
	+ eg. seesaw
* 2nd class
	+ resistance (interchangeable with load) in the middle
	+ eg. pushup
* 3rd class
	+ force in the middle
	+ eg. bicep curl, golf club, baseball bat, tennis racquet
* Force increased by making the force arm longer than resistance arm
* Speed increased by making force arm shorter than resistance arm

Factors affecting Levers

* Length
* Inertia
* Amount of force

Fluid Mechanics

* Fluids of interest
	+ Water and Air
* Fluid forces have little effect on some objects (shot put) but major effects on other objects (shuttlecock)
* Major fluid forces of interest
	+ Drag
	+ Lift
	+ Buoyancy

Drag and Lift

* Inverse relationship
* The greater the disturbance to the fluid, the greater the transfer of energy from object to fluid
* 2 factors affecting fluid resistance:
	+ Density
		- Eg. humid conditions will increase fluid resistance
	+ Viscosity
		- Eg. honey as opposed to water, water as opposed to air

Surface Drag

* Friction produced between fluid and surface of a moving object
* Factors affecting:
	+ Relative velocity of moving object
	+ Relative roughness of surface object
	+ Viscosity of fluid
	+ Surface area of the object

Form Drag

* Resistance created by pressure differential between front and back of an object moving through a fluid
* Factors affecting:
	+ Cross sectional area of object
	+ Velocity of object
	+ Surface roughness
	+ Shape of object

Wave Drag

* Resistance formed by creation of waves at the point where air and water interact
* Factors affecting:
	+ Relative velocity of wave
	+ Technique
	+ Open water vs closed condition

Boundary Layer

* Thin layer of air surrounding or attached to the ball
	+ Laminar – smooth, slow moving ball
		- Early boundary separation
		- Large pressure differential
	+ Turbulent – rough, fast moving ball
		- Later boundary separation,
		- Smaller pressure differential
* Separation
	+ Where boundary layer breaks from ball
	+ Earlier separation occurs, the greater the pressure gradient between the front and back of the ball
* Factors
	+ Velocity
	+ Surface Roughness

Factors affecting drag

* Drag Coefficient
* Cross Sectional Area
* Speed
* Surface Roughness
* Mass
* Shape

Environmental Factors Affecting Drag

* Air Density
* Atmospheric Pressure
* Humidity
* Temperature

Buoyancy

* Archimedes Principle
	+ The buoyant force acting on an object Is equal to the weight of the fluid displaced by the object
* Positive buoyancy
	+ Float
* Negative Buoyancy
	+ Sink
* Neutral buoyancy
	+ Suspends

Bernoulli’s Principle

* Velocity is inversely proportional to pressure
	+ High velocity = low pressure
* Lift occurs when there’s higher pressure below the object

Magnus Effect

* Term used to describe the effect of rotation on an object’s path as it moves through a fluid

Top spin

* High pressure on top of the ball causing it to dip faster



Back Spin

* High pressure of the bottom of the ball causing it to float



Side Spin

* High pressure on one side of the ball causing it to curve the other way

Formula’s to remember:

Force = mass\*acceleration (F=m\*a)

Momentum = mass\*velocity (P=m\*v)

Impulse = force\*time (I=f\*t)

Torque = force\*distance from axis of rotation (t=f\*d)

Moment of inertia = mass\*radius of rotation

Angular Momentum

* Angular velocity\*moment of inertia
* Moment of inertia = mass\*radius of rotation