Phil's Orderly Physics Curriculum Important Concepts List (POPCICL) – Interactive Edition

[Warning : This list is not intended to be comprehensive, but rather to highlight a few key concepts]

Units

The fundamental units of measurement include : _______, _______, _______, & electric _______

Derived units are created from fundamental units by __________ or ___________ (math operations)

You {can/cannot} add, subtract, or equate physical quantities with different units.

Vectors

Vectors are described by two properties : __________ and _________.

You can change a vector quantity by changing either _________ or _________, or both.

You can describe a vector as a single magnitude and direction, or as __________ along mutually __________ axes.

Orthogonal vectors (or vector components) are _________.

Independent variables {do / do not} directly affect one another.

Vector addition is done graphically by placing the _____ of one vector at the _____ of another without _________ either.

Vector subtraction is done graphically by ________ the {first/second} vector and performing vector addition.

Vector addition is done algebraically by adding the individual __________ __________.

A vector dot product between two vectors gives you a {scalar/vector} that represents the component of one of the vectors along the direction of the other vector.

Motion (Kinematics)

Displacement is a {scalar/vector} quantity; distance is a {scalar/vector} quantity.

If you walk in a complete circle, your __________ is zero, but your ____________ is non-zero (and equal the circumference of the circle you just walked)

Velocity is the rate of change of __________ with ______; it tells you how quickly your _______ is changing.

Velocity is a {scalar/vector} quantity; speed is a {scalar/vector} quantity.

If run completely around the block, your ________ ________ is zero because your ______ _________ is zero; but your ________ ________ is a non-zero, positive, {scalar/vector} quantity.

Acceleration is the rate of change of _________ with _____; it tells you how quickly your _______ is changing.

The acceleration due to gravity near the surface of the Earth is equal to __________ directed _________; but if if the y-axis is directed upwards, then the acceleration due to gravity is given by a_y = ______.

Quantities of motion (including ________, ________, and ________) along one orthogonal axis {do / do not} affect the quantities of motion along any other orthogonal axis.

Projectile Motion describes the motion of a object that is in motion and subject only to __________________.

An object in projectile motion (in which we neglect _____ _________), will follow a __________ trajectory.

Forces

Without a ________ __________ applied, objects continue to move with their current velocity, which could be zero. (Newton's First Law)

An object with no net force on it is said to be in ________.

The net force on an object is the ________ ________ of all the forces acting on it.

A net force on an object acts to ___________ it (Newton's Second Law)

Doubling the net force on an object will ________ the resulting acceleration.

For the same applied net force, doubling the mass of the object will ________ the acceleration.

For every force applied by object A onto object B, there is an ________ and __________ force applied by ________ onto ________ (Newton's Third Law)

The force of gravity acts as a force of ________ between the ________ of any two masses.

Near the surface of the earth, the force of gravity is (nearly) ________ and always points ________ ________.

The force of gravity scales ________ly with the mass : double the mass, and the force will ________.

The acceleration due to gravity is {dependent / independent} of mass. If we ignore air resistance, a feather and a bowling ball {will / will not} fall at the same rate.

The restoring force of a spring depends _______ly on the stiffness (k) of the spring and _______ly on how much the spring is compressed (or stretched) from its relaxed length.

An ideal spring is ______less and has no internal ________ (it doesn't ____ ___ just by stretching or compressing)

The ________ force is the force provided by a surface (ground, tabletop) to keep a massive object from breaking through it.

The normal force of a surface always acts ___________ to that surface.

The normal force is a "_____ ________" force. Up to the breaking point, the surface always provides ______ ________ of a counter force to counteract the perpendicular (to the surface) component of other forces pulling/pressing an object against the surface.

________ is the force provided by a flexible connector (rope, string, wire) to keep an object from breaking away from it.

Tension is always directed ____________ the direction of the connector (rope/string/wire)

Tension is a "_____ _________" force. Up to the breaking point, the connector always provides _______ _________ of a counter force to counteract the component of other forces pulling/pressing the object away from the connector.

An ideal rope/string/wire is ________less and does not ________ or ________.

In an ideal rope, the magnitude of the ________ is the same throughout the rope.

An ideal pulley changes the ________ of the tension force but does not change its ________.

The force of friction always acts {parallel / perependicular} to the surface (the interface between the two rubbing objects) and in the direction that __________ the motion or attempted motion.

Static friction acts to oppose ________ motion. Kinetic friction acts to opposes ________ motion. The coefficient of static friction is generally {greater / less} than the coefficient of kinetic friction for the same interface.

Static friction is a "_____ ________" force. Up to the "slipping point", the surface always provides ______ ________ counter force to counteract the parallel (to the surface) component of other forces attempting to push/pull an object along the surface. Kinetic friction is a ________ force between two objects in motions.

Direct Stress or Solid Pressure

Solid pressure (a.k.a. Direct Stress) is the applied _______ per unit _______ on a material when the force (or a component of the force) is applied _____________ to the surface.

The same force applied across a smaller area will result in a _________ solid pressure.

When solid pressure exceeds the "_________ __________ strength" of a material, the material will fracture.

Energy

__________ energy is always conserved. It cannot be created or destroyed; it can only be ________________ ____

There are many forms of energy. Quantitative accounting of some of these forms of energy is difficult (for the beginning physics student), but ____________ energy is straight-forward to calculate.

The Mechanical Energy of an object/system is the sum of the _________ Energies and ______ Energies of that object/system.

Kinetic Energy is the energy of __________. Kinetic energy scales linearly with ______ but quadratically with _________ of the moving object. *Technically, Kinetic Energy is the energy of [coordinated directional] motion; as opposed to the random motion of molecules that make up heat (thermal energy).*

Potential Energy is the energy of _______ ________, shape or configuration of multiple objects (as in the case for _______) or a complex deformable object (as in the case of a ________).

A particle or singular object can only have _______ energy. _______ energy requires having two or more interacting objects.

Spring Potential Energy scales linearly with the _______________, but quadratically with _____________ _________________________

Gravitational Potential Energy near the surface of the Earth scales linearly with the _____of the object and also linearly with the _______ of the object.

________ is the transfer of energy. It has the same units as energy.

Once we have defined what to consider as being in our system, __________ work is a result of forces acting between two objects that are both inside the system. _________ work is a result of a force acting between an object in the system and an object outside the system.

Internal work can be due to [mechanically] conservative forces or [mechanically] non-conservative forces.

Positive work done by conservative internal forces associates with a _________ change in potential energy.

[___________] Conservative Forces (force of gravity, elastic restoring force, *and electric [electrostatic] force*) conserve ___________ energy. [__________] Conservative forces only act to convert one form of __________ energy to another (PE to KE, or KE to PE)

[__________] Non-conservative forces, convert _________ energy to ____________ forms of energy

______________ energy includes heat, light, chemical energy, and nuclear energy.

The force of ___________ converts mechanical energy into heat. We can calculate the amount of heat generated by calculating the work done by the force of friction over a certain ____________.

External work can cause a change in the _______ energy of a system, the _______ energy of a system, or a change in the _______ energy of the system (if, for example, there is ________ between two objects that are both ______ the system)

An increase in internal energy corresponds to a rise in _________.

Power is the rate of change of __________ with _______.

Momentum and Collisions

Linear Momentum is defined as _____ times ______ and it is a vector quantity (it has magnitude and direction)

Total Linear Momentum is always conserved for an ________ system.

A system is an isolated system if there is no transfer of __________ between objects inside the system and anything outside the system.

_______ is the name given to a change in momentum and has the same units as momentum (kg m/s)

Impulse is a measure of the ________ of momentum from one object to another.

(this is similar to how "_______" was the name given to a change or transfer of energy")

Impulse is the integral of an applied force , integrated over ______.

(this is similar to how "work" was the integral of an applied force, integrated over __________)

Newton's second law can be more generally written as : the net force on an object is equal to the change in that object's __________ divided by the duration of the impact.

Momentum is distinct from ______ _______. Two objects can have the same momentum but have different ______ _______. Or two objects can have the same ______ ________ but have different momenta.

A collision with a high kinetic energy object is more likely to cause _______ or ______ of the target while a collision with a high momentum object is more likely to cause __________ of the target.

A collision is any interaction between two objects in which ______ are applied over a relative _____ _____.

In a ______ ________ collision, the colliding objects separate after the collision with their shape undeformed..

In a ______ ________ collision, both total momentum and kinetic energy are conserved.

In a ______ _________ collision, the colliding objects stick together after the collision.

In a ______ _________ collision, total momentum is conserved, but kinetic energy is not conserved.

Two colliding object separating, but ending up deformed after a collision, is an example of an [non-perfect] ________ collision.

For an elastic collision between two objects in one dimension, the _______ _______ between the two objects is the same before and after the collision, but with a sign change to indicate a change in relative direction.

(this is called the _______ ________ _______)

For 2D or 3D collisions, the momentum along each _______ ______ is conserved independently.

Center of Mass

The center of mass of an 1D or 2D object is the location for which the object will be _______ if supported from underneath at that point.

A 3D object will be balanced if the_____ ___ ______ is directly above or below the pivot/suspension point.

The center of mass of a system or object is found by taking a_____-weighted average of the locations of the particle that make up that system or object.

We may treat an extended object as having all its _____ concentrated at its______ ___ _____for the purpose of linear (non-rotational) motion and forces.

For an isolated system, the momentum of the center of mass of the system _____ ______ _____, regardless of any internal forces or collision that occur within the isolated system.

Circular Motion

Acceleration can be decomposed (broken up) into a __________ component that is along the direction of motion (direction of the instantaneous velocity vector at any moment) and a ___________ component that is perpendicular to the direction of motion.

Purely tangential acceleration (along the line of motion) only changes the ________ (________ of the velocity) of an object but not its ____________

Purely centripetal acceleration (perpendicular to the motion) changes the _________ of an object, but not its speed.

Tangential and centripetal and forces {are / are not} new additional forces on a system; they are a ________ of the existing forces (pushing, pulling, gravity, normal, tension, spring, etc) – decomposing the existing force vectors into "along the motion" and "perpendicular to the motion" components instead of the typical x- and y- components.

Rotational Motion

When a force is directed _______ with an object's _____________, it will cause linear acceleration of the object (translational motion) but no rotational motion.

If a force is directed off-center compared to the object's center-of-mass, it can cause _______ of the object.

Rotation is described relative to some _____ ___ _______, such as a fixed pivot point like a hinge.

If an object does not have a fixed pivot point, rotation occurs about its ______________.

Analogous to the four quantities of motion for linear motion (displacement, velocity, acceleration, duration), rotation motion is described by four quantities of rotational motion : _______ _______, _______ _______, _______ _______, and _______)

Angle (θ) and angular displacement (Δθ) is measured in _______ (1 _______ = 57.3° , 2π _______ = 360°)

Angular __________ (__) is measured in radians per second.

Angular ___________ (__) is measured in radians per second-squared.

The (curved) linear distance traveled by a particle undergoing rotation is called the ________ (symbol, __) and is given by the product of the angular _________ (__) and the _____ from ________________ (r)

__________________ is the rotational analog to mass. It is a ______________-weighted total mass of an object.

A moving _________ (non-point-particle) object can have both ___________ and ___________ kinetic energy.

Analogous to translational kinetic energy, rotational kinetic energy is proportional to the object's ______________ and the square of its ______________.

Torque & Angular Momentum

Torque is the rotational analog to _____. Torque is a distance-weighted-_____, and like _____ is a vector quantity.

Torque is the cross product between the _______ vector and the ___________ vector.

A vector cross product between two vectors gives you a vector that represents the how {parallel / perpendicular} the two vectors are to each other. The cross-product's direction is determined by the ______________.

For an extended object to be in static equilibrium, two conditions for equilibrium must be met. The sum of the _______ must be zero, and the sum of the _______ must be zero.

For an object in static equilibrium, you are free to choose the ____________ to be at any point. Choosing it at a point of force application reduces the number of terms in the ____________ equation.

Newton's three laws of motion {do / do not} apply for rotational motion.

An object that is not rotating will _____________________, and an object rotating with constant rotational velocity will ___________________________________ unless acted upon by an external torque.

The net torque on an object is proportional to the its _____________________ and its angular acceleration.

Doubling the net torque on an object will _________ the resulting angular acceleration.

For the same applied net torque, doubling the ______________ will halve the angular acceleration.

For every torque applied by object A onto object B, there is an _____ and _________ torque applied by B onto A.

______________ is the rotational analog to linear momentum.

The angular momentum for a particle is equal to the cross product between the ______________ vector and the ___________________ vector. It's direction is determined by the ______________.

The angular momentum for an extended object is the product of the its ______________ and angular ________.

Angular momentum {is/ is not} always conserved for an ___________ system. If the moment of inertia of an ___________ system is doubled, its angular velocity will be _______.

Analogous to the alternative formulation of Newton's second law for linear motion; torque can be defined as the time derivative of the __________________.