Flipping Physics Lecture Notes:

AP Physics C: Dynamics Review (Mechanics)

https://www.flippingphysics.com/apc-dynamics-review.html

* Newton’s 1st Law: When viewed from an inertial reference frame, an object at rest will remain at rest and an object in motion will remain at a constant velocity unless acted upon by a net external force.

o An inertial reference frame is where the acceleration of the reference frame zero.

o A non-inertial reference frame is where the acceleration of the reference frame is not zero. o Also called the “Law of Inertia”.

* + Inertia is the tendency of an object to resist acceleration.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | ! | ! | ! | ∑ | ! |  | ! |  |  |
|  | *F* |  | *F* | |  |
| • | Newton’s 2nd Law: ∑*F* | = *ma* on the equation sheet it is *a* = | |  | = | *net* | . |  |
| *m* | |  |  |
|  |  |  |  |  | *m* | |  |

* Newton’s 3rd Law: *F*12 = −*F*21!!

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ! | ! | *kg* ⋅ *m* | |  |
| • ∑*F* | = *ma* ⇒ *newtons*, *N* = |  |  |  |
| *s* | 2 |  |
|  |  |  |  |

* The basic forces with which we begin dynamics:

1. Force of Gravity also called Weight. *Fg* = *mg*
   * The force of gravity is caused by the interaction between the object and the planet.
   * The force of gravity is always down.
   * The acceleration due to gravity, g, her on planet Earth is +9.81 m/s2.
   * Sometimes the symbol is W.
   * The force of gravity acts on the center of gravity of the object. (Which is the same as the center of mass in a constant gravitational field like the one we live in.)
2. Force Normal, *FN* : A pushing force caused by a surface.
   * The force normal is normal to (perpendicular to) the surface.
   * The force normal is always a push. (Never a pull. A surface can’t “pull”.)
   * The force normal acts on the contact point between the two surfaces.
3. Force of Tension, *FT* : The force caused by a rope, cable, wire, string, etc.
   * Always in the direction of the rope, cable, wire, string, etc.
   * Always a pull. (Never a push. You can’t “push” with a rope.)
   * Sometimes the symbol is T.
4. Force Applied, *Fa* : The force of one object pushing or pulling on another object.
5. Force of Friction, *Ff* : The force caused by the interaction between two surfaces.
   * With regards to the direction of the Force of Friction. *Ff* always:
     + is parallel to the surface.
     + opposes motion (opposes sliding between the two surfaces)
     + is independent of the direction of the Force Applied.
       - !
   * General formula on the equation sheet: *Ff* ≤ *µ FN*
   * Static friction is when the two surfaces do NOT slide relative to one another.



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!≤*µ*! ! *F F*&*F*

= *µs F*!*N*

* Kinetic friction is when the two surfaces DO slide relative to one another.
  + - !
  + *Fkf* = *µk FN*

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!=− ! *FR bv* .

* The coefficient of friction, *µ* , is an experimentally determined, dimensionless number which depends on the materials of the two interacting surfaces.
* General range is 0 – 2:
  + - * 1. However, *µ* can get up to 4 in extreme circumstances.
      * *µs* > *µk* (For the same two interacting materials.)
* Free Body Diagrams or Force Diagrams. The five steps are …
  1. Draw the Free Body Diagram(s).
  2. Break forces in to components.
  3. Redraw the Free Body Diagram(s).
  4. Sum the forces.
  5. Sum the forces (in a direction perpendicular to the direction in step 4).
     + Only forces are drawn in Free Body Diagrams.
     + When on an incline we will often break the force of gravity in to it’s parallel and perpendicular components and sum the forces in the parallel and perpendicular directions. *Fg*⊥ = *mg* cos*θ* & *Fg*! = *mg*sin*θ*
     + Always draw the Free Body Diagram without breaking forces into components first and then redraw the Free Body Diagram. These are specific instructions from The AP CollegeBoard!
     + When summing the forces you must identify:
       - Positive directions, especially for pulleys!
       - Which object(s) you are summing the forces on.
       - Which direction you are summing the forces in.
     + You can only sum the forces on multiple objects at the same time if they all have the same acceleration.
* Translational equilibrium.

1. Translational motion simply means moving from one location to another.

!

o Translational Equilibrium means the net force acting on the object is zero, ∑*F* = 0 .

1. An object in translational equilibrium is not accelerating.

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∑*F* = 0 = *ma*! ⇒ *a*! = 0 .

* + The object moves with a constant velocity or is at rest.
* The Drag Force or the Resistive Force, *FR* : The force caused by the interaction of an object and the fluid the object is moving through.

o Sometimes the symbol is R or *FD* .

1. Opposite the direction of motion of the object.

o For “small” objects moving at “slow” speeds,

* The resistive force equals the negative of, b, the proportionality constant times the velocity of the object.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ! | = | 1 | *Dρ Av* | 2 |  |  |
| o For all other objects (and more generally applicable), *FR* |  |  | . |  |
| 2 |  |  |

* D is the Drag Coefficient of the object, has no dimensions, is experimentally determined, and depends on the shape and surface texture of the object.
* *ρ* is the density *of the medium* through which the object is moving.
* A is the cross sectional area of the object normal to the direction of motion.
* v is the velocity of the object.

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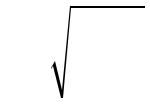
* Terminal velocity is when an object moving through a fluid has reached translational equilibrium. Force example an object which is falling downward in the Earth’s atmosphere has a free body diagram with the force of gravity down and the resistive force up.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | 1 |  |  | 1 | | | *Dρ Av* | 2 | − *mg* |  | *Dρ Av*2 |  |  |
| o ∑*Fy* | = *FR* − *Fg* | = *may* | ⇒ | *Dρ Av*2 | − *mg* = *may* ⇒ *ay* | = |  | 2 |  | = | − *g* |  |
| 2 |  |  | *m* | |  | 2*m* |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |



* In other words, in the absence of air resistance, *ay* = −*g* !!!

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | *Dρ Av*2 | | *Dρ Av*2 |  |  | 2*mg* |  |  |
| o With ay = 0 ⇒ 0 = |  | − *g* ⇒ |  | = *g* ⇒ | *vterminal* = |  |  |  |
| 2*m* | 2*m* | *Dρ A* |  |  |



1. Note: This equation is only true for “an object which is falling downward in the Earth’s atmosphere”. A rocket moving upward will have a different equation for terminal velocity because the free body diagram is different.

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