Exam 1 Outline

Vectors

- Adding vectors graphically (tip-to-tail, chains)
- Subtracting vectors
- Change in vector: $\Delta\vec{v} = \vec{v}_f - \vec{v}_i$ is the vector to add to $\vec{v}_i$ to get $\vec{v}_f$
- Component form of vectors
  - $\hat{x}$, $\hat{y}$, and $\hat{z}$
  - Magnitude: $|\vec{v}| = \sqrt{v_x^2 + v_y^2 + v_z^2}$
  - Trigonometry: $v_x = \pm v\cos\theta$ and $v_y = \pm v\sin\theta$ if θ is measured from the x–axis
  - Adding vectors by components

Basic Kinematics

- Motion diagrams (with the dots)
- Displacement $\Delta\vec{r}$
- Average velocity $\vec{v} = \frac{\Delta\vec{r}}{\Delta t}$
- Speed $v = |\vec{v}|$
- Average acceleration $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$
- Speeding up if $\vec{a}$ and $\vec{v}$ point in same direction; slowing down if in opposite directions
- Graphing position, velocity, or acceleration in one dimension (velocity is slope of position graph, acceleration is slope of velocity graph)

Free Fall

- Objects in free fall feel no force other than gravity
- Accelerate downwards with acceleration $g = 9.8\,\mathrm{m/s^2}$ (on Earth!)
- Turning point: $v = 0$ when object changes direction (in 1D), but $\vec{a} \neq 0$

Uniform Circular Motion

- When objects go around a corner, acceleration points towards center of the turn
- Uniform circular motion is at constant speed
- The velocity is tangent to the circle
- The acceleration is centripetal (towards the center)
- $a = v^2/r$

Constant Acceleration Problems

- Basic procedure
  - Draw a picture.
  - Define coordinate axes (which direction is $+\hat{x}$ or $+\hat{y}$)
  - Identify "initial" and "final" moments of the motion
  - Make a table of variables: fill in what you know, determine what you need, and find the Don't-Know-Don't-Care variable
  - Choose equation without that DKDC variable
  - Solve for what you need
  - Check your answer for sign and magnitude
- The equations mentioned below only work if the acceleration is constant over the entire interval; if the acceleration changes, you might be able to apply the equations to different parts of the motion individually
- Five possible equations (in x or y):
  - $\Delta x = \frac{1}{2}(v_{fx} + v_{ix})t$
  - $v_{fx} = v_{ix} + a_x \Delta t$
  - $\Delta x = v_{ix}\Delta t + \frac{1}{2}a_x(\Delta t)^2$
  - $\Delta x = v_{fx}\Delta t - \frac{1}{2}a_x(\Delta t)^2$
  - $v_{fx}^2 = v_{ix}^2 + 2a_x\Delta x$
- "Drop" means "release without any initial velocity"
- Calculate velocities etc *right after* they leave the hand/gun/etc, and *right before* they hit the ground etc.

One-Dimensional Motion with Constant Acceleration

- Five variables: Δx, v_{ix}, v_{fx}, a_x, Δt (or y or z instead of x)
- The first four are vectors; their sign (positive or negative) depend on the direction you call "positive"
- You can solve for two of these variables; must be given three of them
- Problems with multiple columns (e.g. two stunt cars)

Two-Dimensional Motion with Constant Acceleration

- Different axes (eg. x, y) have their own equations and variables (but share time Δt)
- Motion along different axes are independent of each other
- Know how to solve problems in two dimensions with constant acceleration (e.g. projectile motion)
- You can solve a "column" (x or y) if it has 2 unknowns at most. Δt belongs to both columns.
- If both columns have more than 2 unknowns, then you can solve the problem if the total number of unknowns is 4.
- You can solve one column for Δt, to solve the other column.

Force

- What is a *net force*?
- What is the unit of force?
- What are Newton's Three Laws of Motion?
- What is the difference between an adjustable force and a fixed force?
- What is the difference between contact and noncontact forces?

Free-Body/Force Diagrams

- Draw objects of interest separately from environment
- Label all forces acting on it
- Identify noncontact forces
- Find every point of contact, and determine what forces act there
- Consider the problem of a box sitting on a ramp with angle θ

Gravity

- Near the surface of the Earth, what is the force of gravity on an object?
- $g = 9.8\,\mathrm{m/s^2}$
- What is *weight*?
- What is the difference between mass and weight?
- Gravity is a nonadjustable force.

Normal Force $\vec{N}$

- Normal force is an adjustable push, always perpendicular to the surface of contact.

Tension $\vec{T}$

- An adjustable pull (e.g. by a rope), points along the rope
- A "massless" rope exerts the same magnitude of force on all objects. This is the "tension" in the rope.
- "Ideal" pulleys change the direction of a rope but doesn't affect the tension
- A rope pulls on a pulley at *two* points—where the rope leaves the surface of the pulley—with force T at both points.

Kinetic Friction $\vec{K}$

- Parallel to the contact surface between two objects

- When two objects are *sliding* against each other
- A non-adjusting force; its magnitude is $\left|\vec{K}\right| = \mu_K \left|\vec{N}\right|$ where $\vec{N}$ is the normal force between the two objects
- μ_K is the coefficient of kinetic friction

Static Friction $\vec{S}$

- Parallel to the contact surface between two objects
- When objects are *not* sliding against each other
- An adjustable force (can take multiple values)
- Has a maximum value of $\mu_S \left|\vec{N}\right|$, at which point it "breaks" and turns into kinetic friction
- μ_S is the coefficient of static friction, usually larger than μ_K
- Wheels and walking both move forward via static friction

Newton's Second Law

- If an object is accelerating, $\vec{F}_{net} = m\vec{a}$
- What does it mean when people say that astronauts are "weightless"?

Centripetal Force

- What does "centripetal" mean?
- Explain how different types of forces can be centripetal.
- If an object (mass m) is moving in a circle with speed v and radius R, what is the net force on the object?
- When a bucket of water swings over my head, why doesn't the water spill out?

Newton's Third Law

- What do I mean by a "force twin"? What properties do force twins share?
- Be able to identify a force's twin.