

PHYS-1050-01,02 Exam 2 review guide

Chapter 4 - Dynamics: Newton's Laws of Motion

Force, measured in newtons (N), is how hard a push is. $1 \text{ N} = 1 \text{ kg m/s}^2$.

Types of forces - contact, gravitational, kinetic friction, static friction, others (e.g. electromagnetic, nuclear forces).

Directions of forces - normal force, centripetal force, others.

Newton's first law - Every object continues in its state of rest, or of uniform velocity in a straight line, as long as no net force acts on it.

Inertial reference frame - A reference frame where Newton's first law holds (e.g. in the lab, but not in an accelerating car).

Mass - the amount of stuff in an object. Measured in kg.

Newton's second law - net force on an object = its mass times its acceleration, $\Sigma \mathbf{F} = m\mathbf{a}$.
Often rewritten as $\mathbf{a} = \mathbf{F}/m$.

If an object is stationary, then that implies no acceleration, so forces must cancel.

Acceleration - don't forget chapter 2 and 3 stuff (kinematics in 1 and 2 dimensions), because we will use it to compute acceleration and then forces, or vice versa.

Newton's third law - whenever an object exerts a force on a second object, the second object exerts an equal force in the opposite direction on the first. For a person (P) walking on the ground (G), the force exerted on ground by person equals the force exerted on person by ground: $F_{GP} = -F_{PG}$.

Reaction force - force in response to another force due to Newton's 3rd law.

Weight - the force of gravity on an object. Measured in pounds or newtons. $\mathbf{F}_G = m\mathbf{g}$, $|\mathbf{g}| = 9.81 \text{ m/s}^2$.

Normal force - reaction force that is perpendicular to a surface, often in response to the object's weight. Given as F_N . Important for friction problems.

Free body diagrams - very useful! Know how to draw and read them.

Vector analysis - forces add as vectors. Forces can also be separated into perpendicular components using $\sin\theta$ and $\cos\theta$, like other vectors.

Tension - the tension in a cord, \mathbf{F}_T , is the force exerted along the cord. It is the same at all points of the cord, is parallel to the cord, and is the force exerted at the cord ends.

Kinetic friction force - the force exerted by friction on a sliding object. $F_{fr} = \mu_k F_N$.
Direction is opposite direction of motion.

Static friction force - the force exerted by friction on a stationary object. $F_{fr} \leq \mu_s F_N$.
Direction is opposite of the direction of horizontal force.

Inclines - gravitational force is down, normal force is perpendicular to incline, acceleration, velocity, and friction force are parallel to incline.

Chapter 5 - Circular Motion; Gravitation

Kinematics - in uniform circular motion, speed is constant, velocity is constantly changing, and acceleration is towards the center of the circle.

Centripetal acceleration - acceleration is $a = v^2/r$.

Centripetal force - from Newton's second law, $F = mv^2/r$, towards the circle center.

Centrifugal force - an apparent force in a rotating reference frame (e.g. a car driving around a curve) that points outwards. However, there is no actual outwards force.

Period and frequency - period, T , is time for 1 complete cycle. Frequency, f , is cycles per time. $f = 1/T$. Velocity = $v = 2\pi r/T$.

Banked roads - road is sloped so that normal force points inwards, supplying the centripetal force necessary for a turn. This reduces the need for friction forces. The banking angle is $v^2 = rg \tan\theta$.

Newton's law of gravitation - gravitational force between objects 1 and 2 is in the direction between them and magnitude $F_G = Gm_1m_2/r^2$, with $G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$.

Adding gravitational forces - they add as vectors, just like other forces. The force outside of a spherical body is the same as if all of the body's mass were at the body's center.

Gravity near Earth's surface - acceleration of object 1 from gravity of object 2 (e.g. the Earth) is $a = F_G/m_1 = Gm_2/r^2$. If m_2 is the Earth, then $a = g = 9.81 \text{ m/s}^2$.

Satellites - satellites are in orbit. They are constantly falling (centripetal acceleration) but have a large enough tangential velocity that they never hit the Earth.

Apparent weightlessness - Things in orbit do *not* have apparent weightlessness due to lack of gravity. They seem weightless because no normal force counteracts gravity; instead, person, spaceship, and scale all fall together.

Tides - Tides arise from the differences of the Moon's gravity on different regions of the Earth.

Equations - following are all of the important equations from chapters 1 to 5

You will be given these for the exam (but formatted slightly more nicely).

chapters 1-3

$$v_{average} = \Delta x / \Delta t$$

$$v = dx/dt$$

$$x = x_0 + vt$$

$$a_{average} = \Delta v / \Delta t$$

$$a = dv/dt$$

$$v = v_0 + at$$

$$x = x_0 + v_0t + at^2/2$$

$$v^2 = v_0^2 + 2a(x-x_0)$$

$$v_{average} = (v_0+v)/2$$

$$x = length * \cos(angle)$$

$$y = length * \sin(angle)$$

$$length = (x^2 + y^2)^{1/2}$$

$$angle = \text{Atan}(y/x) (+180^\circ?)$$

$$x = x_0 + v_{0x}t$$

$$y = y_0 + v_{0y}t + a_y t^2/2$$

chapters 4-5

$$\sum \mathbf{F} = m\mathbf{a}$$

$$F_{GP} = -F_{PG}$$

$$F_G = mg, g = 9.81 \text{ m/s}^2$$

$$F_{fr} = \mu_k F_N$$

$$F_{fr} \leq \mu_s F_N$$

$$a = v^2/r$$

$$F = mv^2/r$$

$$f = 1/T$$

$$v = 2\pi r/T$$

$$v^2 = rg \tan\theta$$

$$F_G = Gm_1m_2/r^2, G = 6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$$

$$g = Gm_E/r_E^2 = 9.81 \text{ m/s}^2, m_E = 5.98 \times 10^{24} \text{ kg}$$

$$r_E = 6.38 \times 10^6 \text{ m}$$