

Semester One Final Exam Review Guide KEY

This study guide is an attempt to give you a broad overview of the topics we have studied first semester in physics, along with example problems for you to practice in preparation for your final exam. It is impossible to cover every detail of the whole semester in such a short guide so you should also review all of your returned exams and unit packets full of class work and homework. It is here that you will be reminded of the concepts that were most challenging and those are a good place to focus your energy as you prepare. Spend some time everyday studying physics – do not try to cram it all in the night before the final.

Motion and Forces

Newton's laws predict the motion of most objects. As a basis for understanding this concept, students know:

- how to solve problems involving constant speed and average speed.
 - If Chance Legstrong pedals his bike along a flat straight rode at a constant velocity of 15 m/s, how far will he travel in half an hour?

30 min (60 sec/min) = 1800 sec
 $x = vt \rightarrow (15\text{m/s})(1800\text{s}) = 27000\text{m}$ or 27km

- During Greg Lemond's record-breaking ride in the final stage of 1989, he averaged 54km/hr. If the course was 25 km long, how many minutes did it take Lemond to finish the course?

About 28 minutes

- A child's ice cream starts from rest and falls 1.2 meters to the floor at her feet. What is the speed of the ice cream just before it hits the ground? What is the ice cream's average speed?

4.9 m/s; avg. speed is 2.45m/s

- Who had the highest average speed from start to finish...the tortoise or the hare?
 Tortoise. He covered the whole distance (delta x) in less time. $V_{\text{avg.}} = \Delta x/t$

- when forces are balanced no acceleration occurs, and thus an object continues to move at a constant speed or stays at rest (Newton's First Law).
 - Can an object be moving and have no net force on it? How? Yes if it is moving at a constant velocity... $F_{\text{net}} = ma$...and since constant velocity means zero acceleration, then F_{net} must be equal to zero.
 - Does an object at rest ALWAYS have zero net force on it? Yes
 - What is the difference between mass and inertia? Mass is the physical measurement (in kg) of inertia of an object. Inertia is the degree to which objects resist changes in motion.

- What is the difference between mass and weight? What are the units of each?
 Mass is a quantity of an object's inertia and is constant everywhere. Units are kilograms.
 Weight is equal to the objects mass times the acceleration due to gravity (mg) and the quantity "g" varies depending on the location in the universe of an object. For example on earth "g" is 9.8m/s/s. On the moon it is approx. 1.67 m/s/s. Units of weight are Newtons.
 - What is the mass of a person that weighs 800N?
 The mass of a person that weighs 800N on earth's surface is approx. 80 kg.
 - What is the weight of a 15kg bag of tennis balls?
 150N

□ How to apply the law $F_{\text{net}} = ma$ to solve one-dimensional motion problems involving constant forces (Newton's Second Law).

- Why do heavy things fall at the same rate as lighter objects (ignoring air resistance)?
 Newton's 2nd law states that an object's acceleration is directly proportional to the force on an object but inversely proportional to its mass. Heavier objects have a greater force of gravity on them but they are also harder to accelerate.

$$a = F/m \rightarrow a = \cancel{mg}/\cancel{m} \rightarrow a = g$$

- If a skier of mass 120kg slows down at a rate of 3m/s/s on a flat trail, what is the net force on the skier?

$$F_{\text{net}} = ma \rightarrow (120\text{kg})(3\text{m/s/s}) = 360\text{N}$$

- What are the units of force? Newtons (N)
- Acceleration? Meters per second squared (m/s/s or m/s²)

- If an object experiences a force of 10N to the right and 22N to the left, what is the net force on the object? If it accelerates at a rate of 24 m/s/s, what is the object's mass?

$$a = F/m \rightarrow 24 \text{ m/s/s} = (10\text{N}-22\text{N}) / m \rightarrow m = 12\text{N}/24\text{m/s/s} = 0.5\text{kg}$$

- Draw a free body diagram for the following:
 - a baseball traveling straight upward after being thrown
 - a sled being pulled by a horse through wet snow
 - a satellite in orbit
 - a car rounding a turn at a constant velocity
 - a person in an elevator accelerating upwards
 - a car moving at a constant speed on a horizontal road
 - a person at the bottom of a swing
 - a person on a rollercoaster at the top of the loop
 - a tennis ball being hit by a racquet.

when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and opposite direction. (Newton's Third Law).

○ What pulls harder, the Earth on the Moon or the Moon on the Earth? **same**

○ A bully pushes a little kid and the little kid falls back. Did Newton's third law break down? Explain. **No, the force that bully puts on kid is equal to the force the kid puts on the bully. The same force causes the smaller kid to accelerate more than the bigger bully.**

the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of the Earth.

○ Use the universal law of gravitation to find the force the earth puts on an elephant whose mass is 2000 kg. ($M_e = 5.98 \times 10^{24}\text{kg}$, $r_e = 6.38 \times 10^6 \text{ m}$, $G = 6.67 \times 10^{-11}$)

19600N

applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (for example, the Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).

○ Calculate the frictional force on a 3000kg car rounding a 6m-radius curve at a speed of 35 m/s.

612,500N

○ The tension in the string twirling a 450-gram tennis ball in a 80 cm radius circle is 47N. What is the velocity of the ball?

9.1 m/s

circular motion requires application of a constant force directed toward the center of the circle.

○ If an object travels in a circular path at a constant speed is it accelerating?

Yes – it is centripetal acceleration (toward the center of the circle) and equal to the velocity of the object squared divided by the radius of the circle.

○ How many accelerators does your car have?

3 - gas, break, steering wheel

how to solve two-dimensional trajectory problems.

○ A bowling ball rolls horizontally off a cliff with a velocity of 38 m/s and lands 200 meters from the edge of the cliff. How long does the ball take to hit the ground? How tall is the cliff?

5.26s; 138m

how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.

- A cannon is fired with an initial velocity 600 m/s at an angle of 30°. What is the initial horizontal velocity (v_x)? What is the initial vertical velocity (v_y)?

$$V_x = 520\text{m/s}; v_y = 300\text{ m/s}$$

- A football is thrown with an initial horizontal velocity of 14 m/s and an initial vertical velocity of 8 m/s. What is the total initial velocity of the football?

$$16.12\text{ m/s}$$

how to solve problems in circular motion, using the formula for centripetal acceleration in the following form: $a = v^2/r$.

- A rubber stopper of mass 12 grams makes 30 revolutions in 10 seconds. If the tension in the string is 4N – what is the radius of the circle?

$$F_t = mv^2/r \rightarrow m(2\pi(r)f)^2/r \rightarrow m4(\pi^2)rf \text{ so...}$$
$$r = F_t/(m4\pi^2f^2)$$

$$0.29\text{ m}$$

Conservation of Momentum

The laws of conservation of momentum provide a way to predict and describe the movement of objects.

how to calculate momentum as product mv .

- What has more momentum...a Mack truck at rest or a matchbox car moving at 10 m/s?

Matchbox car

- Calculate the momentum of a 1500kg car of moving 36 m/s.

$$54000\text{ kgm/s}$$

momentum is a separately conserved quantity, different from energy.

- What is the total momentum of a cannon and cannonball before it is fired? **Zero** What is the total momentum afterwards? **zero**

an unbalanced force on an object produces a change in its momentum.

- A 70kg stationary person playing full-contact origami gets tackled by his opponent. After the tackle he is moving 14 m/s. If the contact lasts for 0.27s, what force did the player experience? $F = m (\Delta V)/t$ **3629N**

- If a bocce ball experiences a 60N force for 0.15s, what impulse does it experience?

9 kgm/s

how to solve problems involving elastic and inelastic collisions in one dimension using the principles of conservation of momentum.

- A 10kg ball of clay traveling at 12m/s hits a 5kg ball of clay traveling at 10m/s in the opposite direction. What is the speed and direction of the clump after the collision?

4.66 m/s in pos. direction

- A 3 kg bowling ball moving 6m/s collides with a 4.5kg bowling ball initially at rest. If the heavier ball moves 2m/s after the collision, what is the final velocity of the lighter ball?

3 m/s in the pos. direction

Waves

Waves have characteristic properties that do not depend on the type of wave.

As a basis for understanding this concept, students know:

waves carry energy from one place to another.

- What happens to matter as wave energy moves through it?

how to identify transverse and longitudinal waves in mechanical media such as springs, ropes, and the Earth (seismic waves).

- Is “the wave” at a crowded sporting event a transverse or longitudinal wave?

transverse

- Is sound a transverse or longitudinal wave?

longitudinal

- Which type of waves involves areas of compression?

longitudinal

- What happens when two positive pulses in a rope traveling in opposite direction overlap?

Constructive interference – they add up

- What if one pulse is up and one is down? What is this called?

Destructive interference – amplitudes subtract

how to solve problems involving wavelength, frequency, and wave speed.

- Calculate the speed of a wave with a frequency of 444 Hz and a wavelength of 120 cm.

$V = f(\lambda)$ so $v = 532.8\text{m/s}$

- What is the frequency of a plucked string whose length is 50 cm and on which the waves travel at a speed of 200 m/s? wavelength is twice the string length

200 Hz

- What is the wavelength of a wave produced by a tuning fork of 345Hz when it resonates in a closed pipe that is 34 cm long?

1.36m $L = 1/4(\lambda)$

sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.

- Does sound travel faster in hot air or cool air? **hot**
- Does sound travel faster in air or water? **water**
- Does sound travel faster in solids or liquids? **solids**

how to identify the characteristic properties of waves: interference (beats), Doppler effect

- If two trumpet players try to tune to 440Hz but they hear a beat frequency of 2, how far off are their frequencies? **2 Hz**

- If a buzzer of 330Hz is sounded next to a buzzer of unknown frequency, a beat frequency of 3 is heard. What is the frequency of the unknown buzzer? How could you know for sure? **Either 333Hz or 327Hz; know for sure by testing with another tuning fork like 325Hz**