SPH3U

Grade 11 Physics — Practice Workbook

Ontario Grade 11 Physics (SPH3U)

8 lessons • 120 multiple-choice • 40 short-answer questions

Work through each lesson's questions, then check the Answer Key at the back. Pairs with the interactive Grade 11 Study Hub.

Student notebook handouts

The video-distilled physics notebooks are linked here for quick printing or review.

Open Physics notebook index

Unit 1 Kinematics: handwritten | visual notebook

Unit 2 Forces: handwritten | visual notebook

Unit 3 Energy: handwritten | visual notebook

Unit 4 Electricity & Magnetism: handwritten | visual notebook

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Unit 6 Thermal Review: handwritten | visual notebook

1.1 Kinematics

Key formula / rule: $d = v_0 t + \frac{1}{2}at^2$

Big idea: Physics describes patterns with variables and units.

Multiple choice

1. If acceleration is 0, what stays constant?
A. Time
B. Position
C. Mass
D. Velocity

2. A car starts at rest ($v_0 = 0$) with $a = 2$ m/s². How far does it travel in 3 s?
A. 18 m
B. 3 m
C. 9 m
D. 6 m

3. A car starts at rest ($v_0 = 0$) with $a = 2$ m/s². How far does it travel in 3 s?
A. 18 m
B. 3 m
C. 6 m
D. 9 m

4. An object moves at $v_0 = 5$ m/s with $a = 0$ for 4 s. How far does it go?
A. 5 m
B. 9 m
C. 40 m
D. 20 m

5. If acceleration is 0, the velocity is…
A. zero
B. constant
C. always decreasing
D. always increasing

6. Starting from rest with $a = 10$ m/s², what is the velocity after 2 s?
A. 10 m/s
B. 20 m/s
C. 40 m/s
D. 5 m/s

7. What are the units of acceleration?
A. m/s²
B. s
C. m
D. m/s

8. Positive acceleration with positive velocity means the object is…
A. slowing down
B. speeding up
C. at rest

D. reversing

9. With $v_0 = 10$ m/s and $a = -2$ m/s², what is the velocity after 5 s?
A. 20 m/s
B. 0 m/s
C. −10 m/s
D. 5 m/s

10. In $d = v_0t + \frac{1}{2}at^2$, what is d at t = 0?
A. 0
B. ½a
C. v_0
D. a

11. A ball is dropped from rest ($a \approx 9.8$ m/s²). Its speed after 1 s is about…
A. 9.8 m/s
B. 19.6 m/s
C. 4.9 m/s
D. 1 m/s

12. Distance is measured in…
A. m/s
B. seconds
C. metres
D. newtons

13. A cart starts from rest with $a = 2.0$ m/s² for 3.0 s. What is its final velocity?
A. 6.0 m/s
B. 1.5 m/s
C. 9.0 m/s
D. 3.0 m/s

14. In the same cart problem, what is the displacement after 3.0 s?
A. 9.0 m
B. 3.0 m
C. 18 m
D. 6.0 m

15. Before substituting values in a vector kinematics problem, the distilled teacher move is to…
A. use speed instead of velocity
B. choose a positive direction
C. combine horizontal and vertical motion
D. drop every negative sign

Short answer

1. Explain the difference between velocity and acceleration.

2. A car starts at 4 m/s and accelerates at 3 m/s² for 5 s. Find the distance travelled and the final velocity.

3. What does a negative acceleration mean for an object moving in the positive direction?

4. List the steps you would use to solve a kinematics problem.

5. A cart starts from rest and accelerates at 2.0 m/s² for 3.0 s. Find final velocity and displacement.

1.2 Motion Graphs

Key formula / rule: Slope on position-time graph = velocity

Big idea: A graph is a compact story of motion.

Multiple choice

1. On a position-time graph, what does the slope represent?
A. Force
B. Acceleration
C. Distance
D. Velocity

2. A position-time graph is a flat horizontal line. What does that mean?
A. The object is speeding up
B. The object is accelerating
C. The object moves at constant speed
D. The object is at rest

3. On a position-time graph, the slope represents...
A. distance
B. force
C. velocity
D. acceleration

4. A horizontal line on a position-time graph means the object is...
A. speeding up
B. moving fast
C. accelerating
D. at rest

5. A steeper slope on a position-time graph means...
A. greater speed

B. no motion
C. lower speed
D. more mass

6. A straight (slanted) line on a position-time graph means…
A. random motion
B. acceleration
C. rest
D. constant velocity

7. A curved position-time graph means…
A. changing velocity (acceleration)
B. constant velocity
C. zero force
D. rest

8. On a velocity-time graph, the slope represents…
A. acceleration
B. force
C. distance
D. velocity

9. A negative slope on a position-time graph means the object is…
A. speeding up only
B. at rest
C. moving in the negative direction
D. stopped

10. A horizontal line on a velocity-time graph means…
A. rest always
B. speeding up
C. constant velocity
D. increasing acceleration

11. The area under a velocity-time graph gives…
A. distance (displacement)
B. force
C. speed only
D. acceleration

12. When reading any motion graph, check the … first.
A. colour
B. axes
C. legend box
D. title font

13. On a velocity-time graph, the area under the graph represents…
A. force
B. displacement
C. acceleration
D. mass

14. On a position-time graph, a steeper straight line means…

A. larger mass
B. less time passing
C. zero displacement
D. larger velocity magnitude

15. When reading a motion graph, the safest first question is…
A. What formula can I force onto it?
B. Is the useful feature slope, area, intercept, or trend?
C. Is the object definitely at rest?
D. Can I ignore the axes?

Short answer

1. Explain what the slope represents on (a) a position-time graph and (b) a velocity-time graph.

2. Describe the motion shown by a straight slanted line versus a curved line on a position-time graph.

3. What does the area under a velocity-time graph represent?

4. A position-time graph is flat, then slopes upward. Describe the motion in words.

5. Explain the difference between slope on an x-t graph and area on a v-t graph.

2.1 Forces

Key formula / rule: $F_{net} = ma$
Big idea: Unbalanced forces change motion.

Multiple choice

1. If F_{net} = 12 N and mass = 3 kg, what is the acceleration?
A. 36 m/s^2
B. 0.25 m/s^2
C. 4 m/s^2
D. 9 m/s^2

2. A box is pushed right with 20 N while friction pushes left with 8 N. What is the net force?

A. 12 N left
B. 8 N right
C. 28 N right
D. 12 N right

3. If F_net = 12 N and m = 3 kg, what is the acceleration?
A. 0.25 m/s²
B. 36 m/s²
C. 4 m/s²
D. 9 m/s²

4. A box is pushed right with 20 N while friction pushes left with 8 N. The net force is…
A. 12 N right
B. 12 N left
C. 28 N right
D. 8 N right

5. What is Newton’s second law?
A. F = a/m
B. F = mv
C. F_net = ma
D. F = m/a

6. If all forces balance, the net force is…
A. negative
B. equal to the weight
C. 0
D. maximum

7. With m = 2 kg and a = 5 m/s², the net force is…
A. 2.5 N
B. 7 N
C. 10 N
D. 3 N

8. The unit of force is the…
A. m/s²
B. joule (J)
C. newton (N)
D. kilogram (kg)

9. Doubling the net force (same mass) does what to acceleration?
A. triples it
B. doubles it
C. no change
D. halves it

10. Doubling the mass (same net force) does what to acceleration?
A. halves it
B. no change
C. doubles it
D. triples it

11. A net force of zero means the object…

A. must accelerate
B. speeds up
C. is always at rest
D. keeps constant velocity

12. To find the net force, you…

A. add all forces with direction
B. multiply the forces
C. use only the largest
D. ignore friction

13. A 3.0 kg object has a net force of 12 N to the right. What is its acceleration?

A. 36 m/s² right
B. 12 m/s² left
C. 0.25 m/s² right
D. 4.0 m/s² right

14. A spring has k = 200 N/m and is stretched 0.050 m. What is the spring force magnitude?

A. 200 N
B. 10 N
C. 4.0 N
D. 0.25 N

15. Before writing force equations, the distilled teacher move is to…

A. choose any formula from memory
B. cancel gravity
C. draw the free-body diagram
D. guess the acceleration

Short answer

1. State Newton’s second law and explain what "net force" means.

2. A 4 kg box has 30 N pushing right and 18 N of friction pushing left. Find the net force and the acceleration.

3. Explain how an object can move at constant velocity even though forces act on it.

4. Describe how to draw and use a free-body diagram.

5. A 3.0 kg block has a 12 N net force to the right. Draw the force-equation setup and find acceleration.

2.2 Energy

Key formula / rule: $E_p = mgh$, $E_k = \frac{1}{2}mv^2$

Big idea: Energy ideas connect motion and position.

Multiple choice

1. Which change has the biggest effect on kinetic energy?
A. Halving time
B. Doubling distance
C. Doubling speed
D. Doubling height

2. A 2 kg object sits 5 m high. What is its potential energy? ($g = 9.8\ m/s^2$)
A. 98 J
B. 10 J
C. 49 J
D. 19.6 J

3. Which change has the biggest effect on kinetic energy?
A. halving time
B. doubling distance
C. doubling speed
D. doubling height

4. A 2 kg object is 5 m high ($g = 9.8\ m/s^2$). Its potential energy is…
A. 49 J
B. 19.6 J
C. 98 J
D. 10 J

5. A 2 kg object moves at 3 m/s. Its kinetic energy is…
A. 3 J
B. 18 J
C. 9 J
D. 6 J

6. The unit of energy is the…
A. newton (N)
B. watt (W)
C. joule (J)
D. metre (m)

7. Gravitational potential energy depends on…
A. speed only
B. mass, gravity, and height
C. time

D. voltage

8. Kinetic energy depends on…
A. charge
B. time
C. height only
D. mass and speed (squared)

9. Doubling the speed multiplies kinetic energy by…
A. 4
B. 8
C. 1
D. 2

10. Lifting an object higher gives it more…
A. charge
B. mass
C. potential energy
D. kinetic energy

11. A 4 kg object moves at 2 m/s. Its kinetic energy is…
A. 8 J
B. 16 J
C. 2 J
D. 4 J

12. As a ball falls, its potential energy converts to…
A. charge
B. sound only
C. mass
D. kinetic energy

13. If Wnet = 50 J on an object that starts from rest, what is its final kinetic energy?
A. 25 J
B. 50 J
C. 100 J
D. 0 J

14. If speed doubles, kinetic energy becomes…
A. four times as large
B. twice as large
C. unchanged
D. half as large

15. The sign of work mainly depends on…
A. the direction of force compared with displacement
B. mass only
C. the colour of the object
D. time only

Short answer

1. Write the formulas for kinetic energy and gravitational potential energy and define each variable.

2. A 3 kg ball is 4 m high (g = 9.8). Find its potential energy. It then moves at 5 m/s — find its kinetic energy.

3. Explain why doubling the speed has a bigger effect on kinetic energy than doubling the mass.

4. Describe the energy change as a ball falls from a height.

5. Use the work-energy theorem to explain what happens when Wnet = 50 J and the object starts from rest.

3.1 Waves

Key formula / rule: $v = f\lambda$

Big idea: Different wave quantities are connected.

Multiple choice

1. If f = 3 Hz and λ = 2 m, what is the wave speed?
A. 5 m/s
B. 6 m/s
C. 1.5 m/s
D. 8 m/s

2. If wave speed stays the same and frequency increases, what happens to wavelength?
A. It stays the same
B. It becomes zero
C. It decreases
D. It increases

3. If f = 3 Hz and λ = 2 m, the wave speed is…
A. 6 m/s
B. 5 m/s
C. 8 m/s
D. 1.5 m/s

4. If wave speed is fixed and frequency increases, the wavelength…

A. increases
B. becomes zero
C. decreases
D. stays the same

5. The wave speed formula is…
A. $v = f + \lambda$
B. $v = \lambda / f$
C. $v = f / \lambda$
D. $v = f\lambda$

6. Frequency is measured in…
A. hertz (Hz)
B. metres (m)
C. joules (J)
D. seconds (s)

7. Wavelength is the distance between…
A. the start and the source
B. the top and middle
C. two crests
D. two unrelated points

8. If $f = 4$ Hz and $\lambda = 0.5$ m, the wave speed is…
A. 2 m/s
B. 0.125 m/s
C. 4.5 m/s
D. 8 m/s

9. A wave’s amplitude is related to its…
A. wavelength
B. frequency
C. energy (height)
D. speed

10. Higher frequency at the same speed means a…
A. slower wave
B. shorter wavelength
C. longer wavelength
D. larger amplitude

11. If $v = 10$ m/s and $\lambda = 2$ m, the frequency is…
A. 8 Hz
B. 20 Hz
C. 5 Hz
D. 2.5 Hz

12. Waves transfer…
A. mass
B. charge
C. temperature only
D. energy

13. A wave has f = 3.0 Hz and λ = 2.0 m. What is the wave speed?

A. 1.5 m/s
B. 5.0 m/s
C. 6.0 m/s
D. 9.0 m/s

14. A transverse wave has particle motion…

A. parallel to wave travel
B. only in circles
C. perpendicular to wave travel
D. with no oscillation

15. A mechanical wave transfers…

A. matter permanently across the whole path
B. mass into nothing
C. energy through a medium
D. charge only

Short answer

1. State the wave equation and define each term with its unit.

2. A wave has frequency 5 Hz and wavelength 0.4 m. Find its speed.

3. If the wave speed is constant and the frequency doubles, what happens to the wavelength? Explain.

4. Explain the difference between amplitude and wavelength.

5. A wave has frequency 3.0 Hz and wavelength 2.0 m. Find speed and explain what the medium particles do.

3.2 Sound

Key formula / rule: Higher frequency → higher pitch

Big idea: Sound properties connect directly to wave properties.

Multiple choice

1. What property of a sound wave changes the pitch?
A. Amplitude
B. Voltage
C. Frequency
D. Mass

2. What property of a sound wave controls loudness?
A. Frequency
B. Amplitude
C. Speed
D. Wavelength

3. The pitch of a sound is set by its…
A. speed
B. amplitude
C. frequency
D. colour

4. The loudness of a sound is set by its…
A. amplitude
B. wavelength
C. speed
D. frequency

5. A higher frequency produces a…
A. louder sound
B. higher pitch
C. quieter sound
D. lower pitch

6. Sound needs a … to travel.
A. magnet
B. medium
C. vacuum
D. battery

7. The human hearing range is roughly…
A. 0 to 100 Hz
B. 20 Hz to 20 000 Hz
C. 0 to 20 Hz
D. 1000 to 2000 Hz

8. A bigger amplitude makes a sound…
A. faster
B. quieter
C. louder
D. higher pitched

9. Is a high-pitched sound always loud?
A. Yes
B. Only at night
C. Always
D. No

10. Sound is which type of wave?

A. mechanical
B. electromagnetic
C. light
D. radio

11. Two sounds with the same loudness but different pitch differ in…

A. volume
B. energy per cycle
C. frequency
D. amplitude

12. In a vacuum, sound…

A. cannot travel
B. is louder
C. has no frequency
D. travels faster

13. Pitch is most directly connected to…

A. resistance
B. frequency
C. amplitude
D. mass

14. Loudness is most directly connected to…

A. amplitude
B. magnetic field direction
C. charge
D. period only

15. A higher-frequency sound is usually heard as…

A. zero sound
B. higher pitch
C. lower loudness always
D. lower pitch

Short answer

1. Explain how frequency and amplitude relate to what we hear.

2. Why can’t sound travel through a vacuum?

3. Two sounds have the same loudness but one is higher pitched. What is different about them?

4. Give the approximate range of human hearing and define pitch.

5. Compare frequency and amplitude in a sound wave.

4.1 Circuits

Key formula / rule: V = IR

Big idea: Simple circuit quantities are tightly related.

Multiple choice

1. If V = 12 V and R = 4 Ω, what is the current?
   A. 48 A
   B. 3 A
   C. 0.33 A
   D. 8 A

2. If resistance increases while voltage stays the same, the current…
   A. stays the same
   B. increases
   C. becomes zero
   D. decreases

3. If V = 12 V and R = 4 Ω, the current is…
   A. 0.33 A
   B. 3 A
   C. 8 A
   D. 48 A

4. Ohm’s law is…
   A. V = I / R
   B. V = IR
   C. V = I + R
   D. V = R / I

5. If resistance increases and voltage stays the same, the current…
   A. becomes zero
   B. increases
   C. decreases
   D. stays the same

6. If voltage increases and resistance stays the same, the current…
   A. decreases
   B. becomes zero
   C. stays the same
   D. increases

7. The unit of current is the…
A. ohm (Ω)
B. volt (V)
C. ampere (A)
D. watt (W)

8. The unit of resistance is the…
A. volt (V)
B. joule (J)
C. ohm (Ω)
D. ampere (A)

9. If V = 10 V and I = 2 A, the resistance is…
A. 20 Ω
B. 0.2 Ω
C. 8 Ω
D. 5 Ω

10. If I = 3 A and R = 2 Ω, the voltage is…
A. 0.67 V
B. 6 V
C. 1.5 V
D. 5 V

11. Resistance does what to current?
A. creates it
B. stores it
C. increases it
D. opposes (resists) it

12. Voltage is best described as the…
A. resistance
B. power used
C. push that drives current
D. current itself

13. A 12 V battery is connected to a 4 Ω resistor. What is the current?
A. 16 A
B. 48 A
C. 0.33 A
D. 3 A

14. In a simple series path, the current through each element is…
A. always zero
B. the same
C. unrelated to resistance
D. different only because voltage is shared

15. Before naming a magnetic force direction, the distilled teacher move is to…
A. turn the circuit into a gas law
B. ignore current direction
C. memorize one final arrow for every problem
D. set up the correct hand rule carefully

Short answer

1. State Ohm’s law and define each variable with its unit.

2. A circuit has V = 9 V and R = 3 Ω. Find the current.

3. Explain what happens to the current if resistance increases while voltage stays the same.

4. In words, describe the roles of voltage, current, and resistance.

5. A 12 V battery is connected to a 4 Ω resistor. Find current, and state one circuit simplification move.

4.2 Mixed Review

Key formula / rule: Review focus: identify the physics idea first, then choose the equation.

Big idea: Strong physics thinking begins with identifying the model.

Multiple choice

1. Which equation is used for simple electric circuits?

A. $V = IR$
B. $E_p = mgh$
C. $v = f\lambda$
D. $F = ma$

2. Which equation gives the energy of a moving object?

A. $V = IR$
B. $E_k = \frac{1}{2}mv^2$
C. $F = ma$
D. $v = f\lambda$

3. Which equation is used for simple electric circuits?

A. $v = f\lambda$
B. $F = ma$
C. $E_k = \frac{1}{2}mv^2$
D. $V = IR$

4. Which equation gives kinetic energy?
A. $v = f\lambda$
B. $F = ma$
C. $V = IR$
D. $E_k = \frac{1}{2}mv^2$

5. Which equation gives wave speed?
A. $F = ma$
B. $V = IR$
C. $E_p = mgh$
D. $v = f\lambda$

6. Which equation is Newton’s second law?
A. $v = f\lambda$
B. $E_k = \frac{1}{2}mv^2$
C. $F = ma$
D. $V = IR$

7. The slope of a position-time graph is…
A. acceleration
B. force
C. energy
D. velocity

8. The pitch of a sound depends on…
A. mass
B. amplitude
C. frequency
D. speed

9. Which equation gives gravitational potential energy?
A. $E_p = mgh$
B. $v = f\lambda$
C. $V = IR$
D. $E_k = \frac{1}{2}mv^2$

10. The loudness of a sound depends on…
A. frequency
B. wavelength
C. speed
D. amplitude

11. You should always include … with your answers.
A. your name
B. the date
C. units
D. colours

12. Before solving a problem, it often helps to…
A. draw a diagram
B. round early
C. guess the answer
D. skip the units

13. Which pair is correctly matched?

A. V = IR → projectile motion
B. Fnet = ma → concentration
C. v = fλ → waves
D. Wnet = ΔEk → gas law

14. Across the distilled physics notes, the shared teacher routine is…

A. substitute numbers before reading the diagram
B. ignore units until the answer key
C. classify the situation before choosing the formula
D. use one formula for every unit

15. For a mixed physics question, the safest first step is to ask…

A. Can I skip the diagram?
B. Can I change the units later?
C. Which answer choice is longest?
D. What model does this situation belong to?

Short answer

1. Match each equation to its topic: F = ma, v = fλ, V = IR, $E_k = \frac{1}{2}mv^2$.

2. Describe a general strategy for solving any SPH3U problem.

3. Explain why units are essential in physics answers.

4. Give one everyday example each of motion, force, energy, and electricity.

5. List four physics models and the formula or idea that signals each one.

Answer Key

SPH3U — Physics

1.1 Kinematics

Multiple choice

1. D (Velocity) — With zero acceleration there is nothing to change the velocity, so velocity stays constant (position keeps changing).

2. C (9 m) — $d = v_0t + \frac{1}{2}at^2 = 0 + \frac{1}{2}(2)(3^2) = \frac{1}{2}(2)(9) = 9$ m.

3. D (9 m) — $d = v_0t + \frac{1}{2}at^2 = 0 + \frac{1}{2}(2)(3^2) = \frac{1}{2}(2)(9) = 9$ m.

4. D (20 m) — With no acceleration, $d = v_0t = 5 \times 4 = 20$ m.

5. B (constant) — No acceleration means nothing changes the velocity, so it stays constant.

6. B (20 m/s) — $v = v_0 + at = 0 + 10 \times 2 = 20$ m/s.

7. A (m/s²) — Acceleration is a change in velocity (m/s) per second, giving m/s².

8. B (speeding up) — When acceleration and velocity point the same way, the object speeds up.

9. B (0 m/s) — $v = v_0 + at = 10 + (-2)(5) = 10 - 10 = 0$ m/s.

10. A (0) — At t = 0 both terms are zero, so the distance travelled is 0.

11. A (9.8 m/s) — $v = at \approx 9.8 \times 1 = 9.8$ m/s.

12. C (metres) — Distance is a length, measured in metres.

13. A (6.0 m/s) — Use $v = v_0 + at$. Starting from rest gives $v = 0 + (2.0)(3.0) = 6.0$ m/s.

14. A (9.0 m) — Use $\Delta x = v_0t + 1/2\ at^2 = 0 + 1/2(2.0)(3.0^2) = 9.0$ m.

15. B (choose a positive direction) — The notes repeatedly flag sign choice: choose the positive direction first, then keep vector signs consistent.

Short answer

1. Velocity is the rate of change of position (how fast and in which direction). Acceleration is the rate of change of velocity (how the velocity itself is changing).

2. $d = v_0t + \frac{1}{2}at^2 = 4(5) + \frac{1}{2}(3)(5^2) = 20 + 37.5 = 57.5$ m. $v = v_0 + at = 4 + 3(5) = 19$ m/s.

3. The acceleration opposes the motion, so the object slows down (decelerates).

4. Choose a positive direction (sign convention); list the known quantities with units; pick the equation that uses those variables; solve for the unknown; check the units and whether the answer is reasonable.

5. Choose forward as positive. $v = v_0 + at = 0 + (2.0)(3.0) = 6.0$ m/s. $\Delta x = v_0t + 1/2at^2 = 0 + 1/2(2.0)(3.0^2) = 9.0$ m.

1.2 Motion Graphs

Multiple choice

1. D (Velocity) — Slope is rise over run — change in position over change in time — which is exactly velocity.

2. D (The object is at rest) — A horizontal line has zero slope, so the velocity is zero — the object is not moving (at rest).

3. C (velocity) — Slope is change in position over change in time, which is velocity.

4. D (at rest) — Zero slope means zero velocity — the object is not moving.

5. A (greater speed) — A steeper slope is a larger velocity, so a greater speed.

6. D (constant velocity) — A constant slope means a constant velocity.

7. A (changing velocity (acceleration)) — A changing slope means the velocity is changing, which is acceleration.

8. A (acceleration) — Slope of velocity over time is the rate of change of velocity — acceleration.

9. C (moving in the negative direction) — A negative slope means position is decreasing, so motion is in the negative direction.

10. C (constant velocity) — Zero slope on a velocity-time graph means velocity is constant (zero acceleration).

11. A (distance (displacement)) — Multiplying velocity by time gives distance, which is the area under the curve.

12. B (axes) — Always read what the axes represent before interpreting the shape.

13. B (displacement) — The distilled graph move is slope or area first. Area under a velocity-time graph gives displacement.

14. D (larger velocity magnitude) — Slope of a position-time graph is velocity. A steeper slope has a larger velocity magnitude.

15. B (Is the useful feature slope, area, intercept, or trend?) — The source notes emphasize reading the graph feature before calculating.

Short answer

1. (a) On a position-time graph the slope is the velocity. (b) On a velocity-time graph the slope is the acceleration.

2. A straight slanted line means constant velocity (constant slope). A curved line means the velocity is changing, i.e. the object is accelerating.

3. The displacement (distance travelled), since velocity × time gives distance.

4. First the object is at rest (flat line, zero slope). Then it moves in the positive direction at a constant velocity (steady upward slope).

5. Slope on an x-t graph gives velocity. Area under a v-t graph gives displacement. The teacher move is to name the graph feature before doing arithmetic.

2.1 Forces

Multiple choice

1. C (4 m/s²) — Newton’s second law rearranges to a = F_net / m = 12 / 3 = 4 m/s².

2. D (12 N right) — Combine the forces: 20 − 8 = 12 N, pointing in the direction of the larger force (right).

3. C (4 m/s²) — a = F_net / m = 12 / 3 = 4 m/s².

4. A (12 N right) — 20 − 8 = 12 N in the direction of the larger force (right).

5. C (F_net = ma) — Newton’s second law is F_net = ma.

6. C (0) — Balanced forces cancel out, leaving a net force of zero.

7. C (10 N) — F_net = ma = 2 × 5 = 10 N.

8. C (newton (N)) — Force is measured in newtons (N).

9. B (doubles it) — Since a = F_net / m, doubling F_net doubles a.

10. A (halves it) — Since a = F_net / m, doubling m halves a.

11. D (keeps constant velocity) — With no net force the velocity does not change — it stays constant (which may be rest).

12. A (add all forces with direction) — Net force is the vector sum: combine all forces, accounting for direction.

13. D (4.0 m/s² right) — Use Fnet = ma, so a = Fnet/m = 12/3.0 = 4.0 m/s² to the right.

14. B (10 N) — Use F = kx for magnitude: F = (200)(0.050) = 10 N.

15. C (draw the free-body diagram) — The physics notes repeatedly use the free-body diagram as the bridge between the situation and equations.

Short answer

1. F_net = ma. The net force is the single overall force left after combining (adding with direction) all the forces acting on the object.

2. F_net = 30 − 18 = 12 N to the right. a = F_net / m = 12 / 4 = 3 m/s² to the right.

3. If the forces are balanced, the net force is zero, so there is no acceleration and the velocity stays constant.

4. Represent the object as a dot, draw a labelled arrow for each force in its correct direction, choose a positive direction, then add the forces to find the net force and apply F = ma.

5. After the free-body diagram, use ΣF = ma. Taking right as positive: 12 = 3.0a, so a = 4.0 m/s² to the right.

2.2 Energy

Multiple choice

1. C (Doubling speed) — $E_k = \frac{1}{2}mv^2$. Because speed is squared, doubling the speed multiplies kinetic energy by 4 — the largest effect.

2. A (98 J) — $E_p = mgh = 2 \times 9.8 \times 5 = 98$ J.

3. C (doubling speed) — $E_k = \frac{1}{2}mv^2$; because speed is squared, doubling it multiplies E_k by 4.

4. C (98 J) — $E_p = mgh = 2 \times 9.8 \times 5 = 98$ J.

5. C (9 J) — $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 2 \times 3^2 = \frac{1}{2} \times 2 \times 9 = 9$ J.

6. C (joule (J)) — Energy is measured in joules (J).

7. B (mass, gravity, and height) — $E_p = mgh$ uses mass, gravitational field g, and height.

8. D (mass and speed (squared)) — $E_k = \frac{1}{2}mv^2$ depends on mass and the square of the speed.

9. A (4) — Speed is squared, so $2^2 = 4$ times the kinetic energy.

10. C (potential energy) — Greater height increases gravitational potential energy ($E_p = mgh$).

11. A (8 J) — $E_k = \frac{1}{2} \times 4 \times 2^2 = \frac{1}{2} \times 4 \times 4 = 8$ J.

12. D (kinetic energy) — Falling trades height (potential energy) for speed (kinetic energy).

13. B (50 J) — The work-energy theorem says Wnet = ΔEk. Starting from rest means initial Ek = 0, so final Ek = 50 J.

14. A (four times as large) — Ek = 1/2mv², so doubling v multiplies kinetic energy by $2^2 = 4$.

15. A (the direction of force compared with displacement) — Positive, negative, and zero work come from the angle between force and displacement.

Short answer

1. $E_k = \frac{1}{2}mv^2$ (m = mass, v = speed); $E_p = mgh$ (m = mass, g ≈ 9.8 m/s², h = height). Both are measured in joules (J).

2. $E_p = mgh = 3 \times 9.8 \times 4 = 117.6$ J. $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 3 \times 5^2 = 37.5$ J.

3. Kinetic energy depends on v^2, so doubling the speed multiplies E_k by 4. Mass appears to the first power, so doubling mass only doubles E_k.

4. As the ball drops, its height decreases so potential energy falls; that energy converts into kinetic energy as the ball speeds up (total energy is roughly conserved, ignoring air resistance).

5. Wnet = ΔEk = Ek,f − Ek,i. Since Ek,i = 0, Ek,f = 50 J. The final kinetic energy equals the net work added.

3.1 Waves

Multiple choice

1. B (6 m/s) — Wave speed v = fλ = 3 × 2 = 6 m/s.

2. C (It decreases) — Since v = fλ is fixed, when f goes up λ must go down so the product stays constant.

3. A (6 m/s) — v = fλ = 3 × 2 = 6 m/s.

4. C (decreases) — Since v = fλ is constant, a larger f means a smaller λ.

5. D (v = fλ) — Wave speed equals frequency times wavelength: v = fλ.

6. A (hertz (Hz)) — Frequency (cycles per second) is measured in hertz.

7. C (two crests) — One wavelength spans from one crest to the next.

8. A (2 m/s) — v = fλ = 4 × 0.5 = 2 m/s.

9. C (energy (height)) — Larger amplitude means a taller wave carrying more energy.

10. B (shorter wavelength) — With v fixed, raising f lowers λ (v = fλ).

11. C (5 Hz) — f = v / λ = 10 / 2 = 5 Hz.

12. D (energy) — A wave carries energy from place to place without moving matter along with it.

13. C (6.0 m/s) — Use v = fλ = (3.0)(2.0) = 6.0 m/s.

14. C (perpendicular to wave travel) — Transverse wave particles oscillate perpendicular to the direction the wave travels.

15. C (energy through a medium) — The distilled note language is local oscillation plus energy transfer, not particles travelling with the whole wave.

Short answer

1. v = fλ. v = wave speed (m/s), f = frequency (Hz), λ = wavelength (m).

2. v = fλ = 5 × 0.4 = 2 m/s.

3. The wavelength halves. Since v = fλ is fixed, doubling f requires λ to be halved so the product stays the same.

4. Amplitude is the height of the wave (related to its energy). Wavelength is the horizontal distance of one full cycle, e.g. from one crest to the next.

5. v = fλ = 3.0 × 2.0 = 6.0 m/s. Medium particles oscillate locally while the wave transfers energy through the medium.

3.2 Sound

Multiple choice

1. C (Frequency) — Pitch is set by frequency — higher frequency means higher pitch.

2. B (Amplitude) — Loudness depends on amplitude: a bigger amplitude is a louder sound. Frequency sets the pitch instead.

3. C (frequency) — Higher frequency gives a higher pitch.

4. A (amplitude) — Larger amplitude means a louder sound.

5. B (higher pitch) — Pitch rises with frequency.

6. B (medium) — Sound is a mechanical wave and needs particles (a medium) to travel through.

7. B (20 Hz to 20 000 Hz) — People typically hear from about 20 Hz up to 20 000 Hz.

8. C (louder) — Amplitude controls loudness, so bigger amplitude is louder.

9. D (No) — Pitch (frequency) and loudness (amplitude) are independent, so a high pitch can be quiet.

10. A (mechanical) — Sound is a mechanical wave that needs a medium.

11. C (frequency) — Same loudness means same amplitude; different pitch means different frequency.

12. A (cannot travel) — With no medium there are no particles to carry the wave, so sound cannot travel.

13. B (frequency) — Sound pitch is tied to frequency: higher frequency is heard as higher pitch.

14. A (amplitude) — In the student-facing summary, amplitude is the sound-wave property tied to loudness.

15. B (higher pitch) — Frequency controls pitch in the basic sound model.

Short answer

1. Frequency determines pitch (higher frequency = higher pitch). Amplitude determines loudness (larger amplitude = louder sound).

2. Sound is a mechanical wave that needs particles (a medium) to vibrate and pass the energy along. A vacuum has no particles, so sound cannot travel.

3. They have the same amplitude (same loudness) but different frequencies — the higher-pitched sound has the higher frequency.

4. About 20 Hz to 20 000 Hz. Pitch is how high or low a sound seems, and it is set by the frequency.

5. Frequency is tied to pitch: higher frequency means higher pitch. Amplitude is tied to loudness: larger amplitude is heard as louder sound.

4.1 Circuits

Multiple choice

1. B (3 A) — Ohm’s law rearranges to I = V / R = 12 / 4 = 3 A.

2. D (decreases) — From I = V/R, a larger R with the same V gives a smaller current.

3. B (3 A) — I = V / R = 12 / 4 = 3 A.

4. B (V = IR) — Voltage equals current times resistance: V = IR.

5. C (decreases) — From I = V/R, a larger R gives a smaller current.

6. D (increases) — From I = V/R, a larger V gives a larger current.

7. C (ampere (A)) — Current is measured in amperes (A).

8. C (ohm (Ω)) — Resistance is measured in ohms (Ω).

9. D (5 Ω) — R = V / I = 10 / 2 = 5 Ω.

10. B (6 V) — V = IR = 3 × 2 = 6 V.

11. D (opposes (resists) it) — Resistance opposes the flow of current.

12. C (push that drives current) — Voltage is the energy per charge that pushes current around the circuit.

13. D (3 A) — Use V = IR, so I = V/R = 12/4 = 3 A.

14. B (the same) — A series circuit has one current path, so the same current flows through each element.

15. D (set up the correct hand rule carefully) — The notes stress the direction setup: identify current and field, then apply the named hand rule.

Short answer

1. V = IR. V = voltage (volts, V), I = current (amperes, A), R = resistance (ohms, Ω).

2. I = V / R = 9 / 3 = 3 A.

3. The current decreases. From I = V/R, a larger R with the same V gives a smaller current.

4. Voltage is the push (energy per charge) that drives the circuit; current is the flow of charge; resistance opposes that flow.

5. I = V/R = 12/4 = 3 A. A useful move is to simplify the circuit path first, then label current direction and voltage before calculating.

4.2 Mixed Review

Multiple choice

1. A (V = IR) — Ohm’s law, V = IR, describes simple electric circuits. The others are for forces, waves, and energy.

2. B ($E_k = \frac{1}{2}mv^2$) — A moving object has kinetic energy, $E_k = \frac{1}{2}mv^2$. The others describe waves, circuits, and force.

3. D (V = IR) — Ohm’s law, V = IR, describes simple circuits.

4. D ($E_k = \frac{1}{2}mv^2$) — Kinetic energy is $E_k = \frac{1}{2}mv^2$.

5. D ($v = f\lambda$) — Wave speed is $v = f\lambda$.

6. C (F = ma) — Newton’s second law is F = ma.

7. D (velocity) — Slope of position over time is velocity.

8. C (frequency) — Pitch is set by frequency.

9. A ($E_p = mgh$) — Gravitational potential energy is $E_p = mgh$.

10. D (amplitude) — Loudness is set by amplitude.

11. C (units) — A physics answer is incomplete without its units.

12. A (draw a diagram) — A labelled diagram makes the situation clear before you calculate.

13. C ($v = f\lambda$ → waves) — The wave relationship is $v = f\lambda$. The other pairs mismatch a model with the wrong topic.

14. C (classify the situation before choosing the formula) — The source-locked notes repeatedly say model first, equation second, numbers third.

15. D (What model does this situation belong to?) — Mixed review is about recognizing the type: motion, force, energy, waves, sound, circuits, or magnetism.

Short answer

1. $F = ma$ → forces; $v = f\lambda$ → waves; $V = IR$ → electric circuits; $E_k = \frac{1}{2}mv^2$ → (kinetic) energy.

2. Identify the topic/situation; list the known values with units; choose the matching equation; solve; include units and check the answer is reasonable; draw a diagram if it helps.

3. A number on its own is ambiguous. Units give the value meaning and let you check that the equation and dimensions are correct.

4. Sample answers — motion: a car speeding up; force: pushing a door open; energy: a moving ball (kinetic) or a lifted backpack (potential); electricity: current flowing from a phone charger.

5. Examples: kinematics uses signed motion variables; forces use $F_{net} = ma$ after a free-body diagram; energy uses $W_{net} = \Delta E_k$ or conservation language; waves use $v = f\lambda$; circuits use $V = IR$; magnetism uses a careful hand-rule setup.