1. Newton's Laws

Check Point 1.1: This will depend upon your field of study.

Check Point 1.2: (a) and (c); the net force isn't zero if the object's speed or direction is changing.

Check Point 1.3: The two east-west components were opposite in direction (i.e., one was eastward while the other was westward).

$$\Delta\vec{v} = \frac{\vec{F}_{\text{net}}}{m}\Delta t \tag{1.1}$$

$$\vec{a}_{\text{avg}} = \frac{\Delta\vec{v}}{\Delta t} \tag{1.2}$$

Check Point 1.4: Because the electron's mass is so much smaller than the ball's.

Check Point 1.5: 1 N west

2. Mass and the Gravitational Force

Check Point 2.1: (a) magnetic force, (b) gravitational force

Check Point 2.2: The second phrase seems to imply that the force "belongs" to the rock rather than being a consequence of the rock's interaction with another object.

Check Point 2.3: Equal in magnitude.

Check Point 2.4: 0.240 kg (or 240 grams)

$$F_{\mathrm{g}} = G\frac{m_1 m_2}{r^2} \tag{2.1}$$

Check Point 2.5: Yes.

$$\vec{g} = \frac{\vec{F}_{\mathrm{g}}}{m} \tag{2.2}$$

3. Charge and the Electric Force

Check Point 3.1: Rub one balloon with the cloth and then another balloon with the cloth. The two balloons should repel.

Check Point 3.2: (a) the same amount, (b) yes, because the electrons have one-thousandth the mass of the protons

$$F_{\mathrm{e}} = k\frac{q_1 q_2}{r^2} \tag{3.1}$$

Check Point 3.3: (a) charge, (b) electric force

Check Point 3.4: (a) -3.2×10^8 C (multiply one tenth of 2×10^{28} by the charge on an individual electron), (b) -2.9×10^9 C (same as for (a) but with nine-tenths of 2×10^{28} electrons)

Check Point 3.5: Disagree for both. Since the protons carry positive charge and the neutrons are neutral, the electric force should be repulsive, not attractive. The gravitational force is too weaker compared to the electric force to keep the protons together.

4. Nucleons and the Nuclear Force

Check Point 4.1: The nuclear force of attraction between the protons and the other nucleons in the nucleus.

Check Point 4.2: Since they are both carbon, they both have same number of protons (six). That means that Carbon-12 has six neutrons and Carbon-14 has eight.

Check Point 4.3: No. Neutrons are unstable unless they are with protons.

Check Point 4.4: No. During alpha decay, the nucleus loses two neutrons and two protons. The loss of protons means that the element has changed.

Check Point 4.5: Because it doesn't get far though the air before it is stopped by the air. [It is interesting to note that the damage to us is minimal even if swallowed since the material used in a smoke detector is not soluble (not absorbed by us) and passes through our system (Americium-241 has a half-life of 432 years). It would be more dangerous in soluble form.]

5. Magnets and the Magnetic Force

Check Point 5.1: Attract.

Check Point 5.2: Because the north poles of magnets are attracted to it. Since opposite poles attract, that must mean there is a magnetic south pole at the Earth's geographic North pole.

Check Point 5.3: The Earth is so huge that the force on each end of a magnet is the same. Smaller magnets exert a greater force on the closer end.

6. The Flow of Charge

Check Point 6.1: Yes. Although the chairs don't physically leave, they are being replaced by "neutral" combinations of students and chairs. So, in effect, it appears as though the empty chairs have left as the students enter.

Check Point 6.2: That they reside on the surface, not distributed uniformly within the conductor.

Check Point 6.3: The charge would also be distributed around the surface but more concentrated at the points.

Check Point 6.4: An insulator. Although charge, once present, can flow easily throughout the space, it first has to be extracted from another material, and that is very hard. Thus, the vacuum acts like an insulating wall around a conductor.

Check Point 6.5: The charge transfer would result in both becoming neutral.

Check Point 6.6: So that charge doesn't build up on the container and flow through us when we touch it.

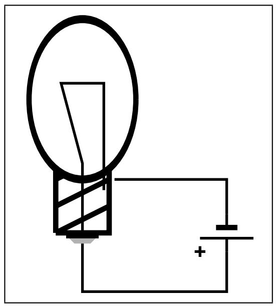
Check Point 6.7: (a) Bring a negatively charged object toward it while it is grounded, (b) Part [b]

Check Point 6.8: (a) Zero, (b) Zero, (c) No

7. Current

Check Point 7.1: The electrons pass through the filament and come out the other end.

Check Point 7.2: One possible arrangement is shown here.



The key is to have one end of the battery connected to the end of the filament, and have the other end of the battery connected to the other end of the filament.

Check Point 7.3: 5000 s

$$I_{\text{average}} = \frac{\Delta q}{\Delta t} \tag{7.1}$$

Check Point 7.4: (a) 1.5 C, (b) 9.38×10^{18}

Check Point 7.5: (a) ii, (b) i

Check Point 7.6: No, the current is the same. Just because the wire doesn't glow doesn't mean there is less current flowing through it. It just means there are less collisions between the moving electrons and the material that makes up the wire.

Check Point 7.7: (a) No, the current has to be the same through each light bulb as whatever charge comes out of the first bulb must go through the second (conservation of charge).
(b) Yes, the current can be different because more charge will go through the bulb that is easier for the electrons to flow through.

Check Point 7.8: The circuit on the right (circuit b). The ammeter measures the current through the meter. So, the question is really "in which circuit is the current through the meter the same as that through the light bulb?"

Check Point 7.9: (a) To the location indicated as $\overline{\text{A}}$.
(b) One wire is connected to the "COM" socket and the other is connected to the "10A" socket (at least initially).

8. Electromagnets

Check Point 8.1: The electromagnet aligns the little magnets inside the metal core, creating an additional magnet that adds to the strength of the electromagnet.

Check Point 8.2: (a) counter-clockwise, (b) right side.

Check Point 8.3: One needs to orient the magnet so that it isn't parallel to the current direction through B. Since the current direction is toward the left (or right), you can orient the magnet up-down or in-out of the page.

Check Point 8.4: Yes, because the direction the electron is moving (into the page) is perpendicular to the orientation of the magnet (left-right).

9. Describing Fields

Check Point 9.1: (a) Toward planet A, (b) toward planet B, (c) toward planet A, (d) toward planet B, (e) the total gravitational field is zero there

Check Point 9.2: (a) Away from particle A, (b) toward particle B, (c) away from particle A/toward particle B, (d) away from particle A/toward particle B, (e) away from particle A/toward particle B

Check Point 9.3: (a) toward magnet B, (b) opposite the direction of magnet B's magnetic field

Check Point 9.4: Toward the right

Check Point 9.5: Because the electromagnet's magnetic field is of equal strength at the location of each end of the permanent magnet. Consequently, the magnitude of the force is the same on each pole (same magnetic field at each end) but of opposite direction (since they have opposite poles).

Check Point 9.6: Toward the west

Check Point 9.7: The magnetic field can be represented by magnetic field vectors directed counter-clockwise around the current location.

10. Measuring Fields

$$\vec{g}_{\text{A}} = \frac{\vec{F}_{\text{g,A on B}}}{m_{\text{B}}} \tag{10.1}$$

Check Point 10.1: You would divide the gravitational force by the mass of the ball. We want to know the Earth's gravitational field. The force is associated with both objects (ball and Earth). By dividing by the ball's mass, we remove the dependence on the ball.

$$\vec{E}_{\text{A}} = \frac{\vec{F}_{\text{E,A on B}}}{q_{\text{B}}} \tag{10.2}$$

Check Point 10.2: Zero. We find the electric field at a location by measuring the electric force on an object at that location (in this case that would be zero) and dividing by the charge of that object.

Check Point 10.3: Tesla.

$$B_{\text{A}} = \frac{\tau_{\text{max,A on B}}}{I_{\text{B}} A_{\text{B}}} \tag{10.3}$$

Check Point 10.4: The stronger magnet has a greater magnetic moment.

Check Point 10.5: (a) 10^{-7} N$\cdot$ m. (b) The torque acts to align the loops with the magnetic field. Once aligned, there is no more torque exerted on the loop.

Check Point 10.6: The dielectric strength of air is 3×10^6 N/C. So, if the electric field was greater than that, the air would break down and create a spark.

$$F_{\text{max,A on B}} = I_{\text{B}} \ell_{\text{B}} B_{\text{A}} \tag{10.4}$$

Check Point 10.7: Yes, there is a magnetic force and it is due to both components, since both components are perpendicular to the direction of the current.

Check Point 10.8: The wire to the right experiences a downward magnetic field (due to other wire). This produces a force on the right wire that is directed perpendicular to both direction of current, in/out, and direction of field, up/down. Whether it is toward the left or right can be determined by the third right-hand rule. That tells us it is toward the left (toward other wire). By Newton's third law, the force on the other wire must be opposite (toward the right). This means the two wires attract one another.

$$F_{\text{max,A on B}} = q_{\text{B}} v_{\text{B}} B_{\text{A}} \tag{10.5}$$

Check Point 10.9: (a) Toward the north, (b) toward the south. We know that the direction for each must be either north or south, with one being the opposite of the other, since the direction must be perpendicular to both the up-down and east-west directions. The direction of the proton can be determined using the third right-hand rule.

Check Point 10.10: (a) There is a magnetic force exerted on the isotopes because their motion is perpendicular to the magnetic field at that location. (b) They should follow bigger circles, because the force is the same on all the isotopes (same speed and same charge, so qvB is the same). However, with the larger mass, their acceleration is less (from Newton's second law).

11. Conservation of Energy

$$E_k = \tfrac{1}{2}mv^2 \tag{11.1}$$

Check Point 11.1: If we replace N by kg·m/s^2 then N·m is equivalent to (kg·m/s^2)·m. Since m·m is m^2, this is equivalent to kg·m^2/s^2, which is a joule.

Check Point 11.2: (a) Loss, much like the dropped rock, (b) no change, as the person started and stopped at rest, (c) energy is always conserved, so the loss in gravitational energy must be accompanied by a gain of *some* type of energy. In this case, it is likely the elastic energy of the bungee cord and the thermal energy of the air and bungee cord.

Check Point 11.3: (a) When the comet is far from the sun, (b) When the comet is close to the sun.

Check Point 11.4: (a) The electric energy of the system decreases, (b) the electric energy of the system increases

Check Point 11.5: (a) The nuclear energy of the system decreases, (b) the nuclear energy of the system increases

$$\Delta E_{\mathrm{g}} = G\frac{m_1 m_2}{r} \tag{11.2}$$

Check Point 11.6: 5.30×10^{33} J

$$\Delta E_{\mathrm{e}} = -k\frac{q_1 q_2}{r} \tag{11.3}$$

Check Point 11.7: Yes. The change in gravitational energy (using the mass of ten neutrons or protons) is 3.52×10^{-52} J, which is much smaller than the change in electric energy.

Check Point 11.8: 3.98×10^{33} J

Check Point 11.9: 2.3×10^{-18} J

12. Chemical Reactions

Check Point 12.1: The electric energy has decreased. In keeping with conservation of energy, if one type increases another type must decrease. In this case, the electric energy has decreased, much like the decrease in electric energy associated with opposite charges that come together.

Check Point 12.2: (b) absorbed, as energy is needed from the environment, which leads to an increase in the system's electric energy.

Check Point 12.3: (a)

Check Point 12.4: (a) 167 kJ, (b) 942 kJ, (c) The value for a mole of N≡N bonds is greater because the N≡N bond is so much stronger (and thus requires more energy to break it).

Check Point 12.5: The products. Since energy is released, that means more energy is released during the formation of the bonds in the products. That means those bonds must be stronger or more stable than those in the reactants.

Check Point 12.6: This ignores the other bonds involved. On average, the bond energy for the bonds in the reactants (which includes the C–H bonds) is smaller than for the bonds in the products (which includes the C=O bonds).

13. Nuclear Reactions

Check Point 13.1: The products. Since energy is released, it must take less energy to break apart the reactants than is released when the product is formed.

Check Point 13.2: It is equal to a large number of electron-volts, since one electron-volt is only a tiny fraction of a joule.

Check Point 13.3: (a) Helium, (b) zero, since the proton is essentially already separated from the other nucleons (there are no others).

Check Point 13.4: 1802 MeV (multiply the binding energy per nucleon, 7.57 MeV/nucleon, by the number of nucleons, 238)

Check Point 13.5: It is easier to extract a proton from a Uranium nucleus. The graph of binding energies indicates that the binding energy for Uranium is lower, which means it takes less energy, on average, to extract a nucleon from the Uranium nucleus.

Check Point 13.6: It produces a net release of energy of 155.8 MeV. This is because the products (Ba-141 and Kr-92) are so much more stable than the original U-238 nucleus (8.33 MeV/nucleon and 8.51 MeV/nucleon compared to 7.57 MeV/nucleon). [Note: the actual energy released in a fission reaction is more than this, because the daughter fragments aren't stable and thus subsequent reactions produce additional energy.]

Check Point 13.7: In the previous chapter, we found that around 800 kJ is released for each mole of methane. The fusion reaction releases about two million times more.

14. Energy, Power and Voltage

$$V = \frac{E}{q} \tag{14.1}$$

Check Point 14.1: Disagree, because the battery provides as much charge via one terminal as it takes out via the other terminal.

Check Point 14.2: (a) 5 V, (b) 2 V

Check Point 14.3: The voltage across the first bulb goes up to 5 V, to match the battery voltage. The voltage across the second bulb goes down to zero (from 2 V).

Check Point 14.4: (a) 5V, (b) 1V

Check Point 14.5: 5 V

Check Point 14.6: The voltage across the burned bulb remains at 5 V, as does the voltage across the other bulb.

Check Point 14.7: 1.5 V

Check Point 14.8: There is no current running through those wires. They are just the probes of the voltmeter.

Check Point 14.9: Circuit (a)

$$P = \frac{\Delta E}{\Delta t} \tag{14.2}$$

Check Point 14.10: 0.6 kWh, 6 cents

$$P = IV \tag{14.3}$$

Check Point 14.11: (a) 1.25 A (divide 150 W by 120 V), (b) 0.5 A (divide 60 W by 120 V), (c) 10 A (divide 1200 W by 120 V)

Check Point 14.12: (a) The lit bulb, since more energy is being dissipated for the same current. (b) The one across the gap, since there is no energy being dissipated at all across the unlit bulb (no current), which means the left voltmeter is essentially just measuring the voltage across the battery.

15. Resistance

$$R_{\text{of element}} = \frac{V_{\text{across element}}}{I_{\text{through element}}} \tag{15.1}$$

Check Point 15.1: 1200 Ω (divide the voltage by the current and remember to convert the current to amps).

Check Point 15.2: The voltage across the bulb, because the voltage and resistance need to correspond to the same element.

$$I_{\text{through element}} = \frac{V_{\text{across element}}}{R_{\text{of element}}} \tag{15.2}$$

$$V_{\text{across element}} = I_{\text{through element}} R_{\text{of element}} \tag{15.3}$$

Check Point 15.3: Multiply the resistance and current to get 1.2 V.

Check Point 15.4: Your answer should be something like "the resistance of an object is the same regardless of the voltage that is applied across it."

$$P = I^2 R. \tag{15.4}$$

Check Point 15.5: (a) The voltage across bulb A because the brighter bulb dissipates energy at a greater rate (i.e., P is greater) and since $P = IV$, if P is greater and I is the same, that means V must be greater. (b) The resistance of bulb A because the brighter bulb dissipates energy at a greater rate (i.e., P is greater) and since $P = I^2R$, if P is greater and I is the same, that means R must be greater.

Check Point 15.6: Equal to 1.50 V

Check Point 15.7: 2 Ω

16. Predicting Current and Voltage

Check Point 16.1: The bulbs should have identical brightness, as the current is the same through all of them.

Check Point 16.2: The bulbs should have identical brightness, as we've assumed the wires have no resistance.

Check Point 16.3: Due to conservation of charge, the current through each of the bulbs in the 3-bulb branch must be a third of that through the 1-bulb branch. That means each of the three bulbs in the 3-bulb branch are dimmer than the bulb in the 1-bulb branch. By the same reasoning, the brightness of the bulbs in the 2-bulb are between those in the 3-bulb branch and the 1-bulb branch. Thus, the brightest is the one in the 1-bulb branch and the dimmest are those in the 3-bulb branch.

Check Point 16.4: 0.5 V across the 1.0-Ω resistor and 1.0 V across the 2.0-Ω resistor. We know that the 1.5 V is split among the two resistors (voltage loop rule), with twice as much across the 2.0-Ω resistor (using $V = IR$ with twice the resistance but the same current, since charge is conserved).

Check Point 16.5: 1.25 A. We know the voltage across each resistor must be 1.5 V. Using $V = IR$, we get the current through each resistor (0.75 A and 0.5 A), which we add together to get the total current.

$$R_{\text{total, in series}} = R_1 + R_2 + R_3 + R_4 + \cdots + R_n \tag{16.1}$$

$$\frac{1}{R_{\text{total, in parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \cdots + \frac{1}{R_n} \tag{16.2}$$

Check Point 16.6: 2 Ω. Invert each resistance to get 0.25 Ω^{-1} for each, then add together to get 0.5 Ω^{-1}. Don't forget to invert this! This gives $R_{\text{total}} = 2\ \Omega$. If you keep track of your units, you'll be able to catch yourself when you inadvertently forget to invert your answer. Also check the answer

- the equivalent resistance of two resistors in parallel has to be less than each individual resistance.

Check Point 16.7: The equivalent resistance must be less than the smallest value (1 Ω in this case), as it must be easier to flow through all of the resistors in parallel than a single 1-Ω resistor.

Check Point 16.8: Using the outer loop clockwise, I get the following expression:

$$-I_{\text{top}}(4.00\ \Omega) + (6.0\ \text{V}) - I_{\text{botom}}(2.00\ \Omega) = 0$$

Using the bottom loop clockwise, I get the following expression:

$$I_{\text{middle}}(8.00\ \Omega) - (16.00\ \text{V}) + (6.0\ \text{V}) - I_{\text{botom}}(2.00\ \Omega) = 0$$

If you do the loops counter-clockwise, you'll get the same results but opposite signs.

Check Point 16.9: The three currents, I_{bottom}, I_{middle} and I_{top}. Everything else we know.

17. Describing AC Circuits

Check Point 17.1: The frequency is 1000 Hz and the angular frequency is 6280 rad/s (or 6280 s^{-1}).

Check Point 17.2: The frequency is 1000 Hz and the angular frequency is 6280 rad/s (or 6280 s^{-1}).

$$V_{\mathrm{rms}} = \frac{V_{\mathrm{max}}}{\sqrt{2}} \tag{17.1}$$

Check Point 17.3: (a) 170 V, (b) maximum value, (c) the square root of 2 is bigger than 1, so dividing the maximum by the square root of 2 should give a smaller value, (d) the RMS value represents a "mean" value, it should be less than the maximum value

Check Point 17.4: About 0.65 V.

Check Point 17.5: Only the resistor that is on the negative side of the oscilloscope (far right in the illustration).

Check Point 17.6: 2 Hz (the voltage undergoes a complete cycle in 1 second, which means that it must be directed one way, then the other way, and then back in one second).

$$V_{\mathrm{max}} = I_{\mathrm{max}} R. \tag{17.2}$$

$$V_{\mathrm{rms}} = I_{\mathrm{rms}} R. \tag{17.3}$$

Check Point 17.7: (a) The RMS voltage, (b) 0.04 V

$$P_{\mathrm{avg}} = I_{\mathrm{rms}} V_{\mathrm{rms}} \tag{17.4}$$

Check Point 17.8: Even though the light appears steady, the current is still oscillating. The product of I_{rms} and V_{rms} represents the average rate at which energy is being converted (as indicated by equation 17.4).

18. Impedance

Check Point 18.1: The impedance in both cases would be 100 Ω, as the impedance is the same as the resistance (at least for the resistor).

Check Point 18.2: (a) Higher, (b) lower

Check Point 18.3: (a) Lower, (b) higher

$$Z = \frac{V}{I} \tag{18.1}$$

$$V = IZ \tag{18.2}$$

Check Point 18.4: 3 Ω

19. Capacitors

Check Point 19.1: (a) Because charge can accumulate for a short time on each plate of the capacitor. During that time, it appears as though current is flowing through the capacitor when, in fact, it is not.
(b) Yes, just as much positive charge is placed on one plate as is removed from the other plate.

Check Point 19.2: (a) 3 Ω, (b) 1.5 Ω, (c) 10 A, (d) infinity, (e) zero

$$Q = CV \tag{19.1}$$

Check Point 19.3: 600 nC

$$Z_{\text{cap}} = \frac{1}{\omega C} \tag{19.2}$$

Check Point 19.4: 8 A. With a greater capacitance, more charge can accumulate before the capacitor gets "filled." One can also use equation 19.2, which shows that the impedance is inversely proportional to the capacitance. That means the impedance will be less with the larger capacitor, allowing for more current to flow.

Check Point 19.5: It is much less than that associated with the cardiac defibrillators

Check Point 19.6: The capacitance doubles also.

$$C = \kappa C_0 \tag{19.3}$$

Check Point 19.7: 6 μF

20. Inductors

Check Point 20.1: Magnetic energy.

Check Point 20.2: Because it increases the strength of the magnet and, as such, more electric energy is converted to/from magnetic energy.

Check Point 20.3: The inductor is in series with the bulb. When the bar is placed in the inductor, the impedance increases, decreasing the current through the inductor. Since the inductor is in series with the bulb, that also decreases the current through the bulb.

Check Point 20.4: It should increase as well.

$$Z_{\text{ind}} = \omega L. \tag{20.1}$$

Check Point 20.5: (a) 3 Ω, (b) 6 Ω, (c) 2.5 A, (d) zero, (e) infinity

Check Point 20.6: The energy stored in a typical capacitor is similar.

Check Point 20.7: The inductance increases also.

21. Magnetic Induction

Check Point 21.1: No current is induced when the magnet remains stationary, as in part (c).

Check Point 21.2: The generation of current would be the same but in the opposite direction.

Check Point 21.3: (a) yes, (b) yes, (c) no, (d) no

Check Point 21.4: (a) no, (b) no, (c) yes

Check Point 21.5: Yes. The force is still toward the left (braking). As it leaves the field, a current loop is induced in the plate that produces a magnetic field to make up for the decreasing externally-applied field. That means the current in the plate must now be clockwise (producing a magnetic field into the page). That means the current in the rear of the plate (which is still within the poles of the magnet) is upward. As before, we have an upward current placed in a region where the magnetic field is into the page.

Check Point 21.6: Method (2) doesn't change the magnetic field inside the solenoid, so that doesn't induce any current to flow. Method (1) changes the magnetic field, but it changes too slowly. Method (3) changes the magnetic field quickly (1000 times every second) and keeps doing it, creating an oscillating current in the solenoid that lights the bulb.

22. Describing Waves

Check Point 22.1: D

Check Point 22.2: B

Check Point 22.3: (a) Longitudinal, (b) both, (c) transverse

Check Point 22.4: 1/300 of a second (i.e., 0.0033 seconds).

Check Point 22.5: 3.5%

Check Point 22.6: 0.75 m

$$v = f\lambda \tag{22.1}$$

Check Point 22.7: 0.5 m

Check Point 22.8: No

Check Point 22.9: 10^{-7} W/m^2, 5 bels, 50 decibels

23. Doppler Effect

Check Point 23.1: (a) The car's horn, moving, (b) you, stationary

Check Point 23.2: (a) higher than 1000 Hz, (b) lower than 1000 Hz

Check Point 23.3: (a) higher than 1000 Hz, (b) lower than 1000 Hz

$$f_{\text{obs}} = f_{\text{emitted}} \frac{v \pm v_{\text{obs}}}{v \pm v_{\text{source}}} \tag{23.1}$$

Check Point 23.4: 108 Hz

Check Point 23.5: 109 Hz

Check Point 23.6: 1000 Hz

Check Point 23.7: Yes. When the observer was moving, the observed frequency was 108 Hz. When the source was moving, the observed frequency was 109 Hz.

24. Interference

Check Point 24.1: Greater than A but less than 2A

Check Point 24.2: $|A - B|$ (i.e., the absolute value of the difference)

$$f_{\text{beat}} = |f_2 - f_1| \tag{24.1}$$

$$f_{\text{average}} = \frac{f_1 + f_2}{2} \tag{24.2}$$

Check Point 24.3: (a) 435 Hz or 445 Hz, (b) 445 Hz

Check Point 24.4: Gray (between light and dark)

$$\frac{\Delta \ell}{\lambda} = \text{whole number} \qquad \text{[constructive]} \tag{24.3}$$

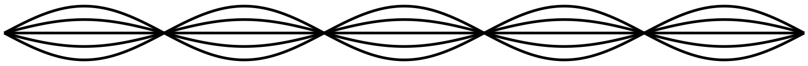
Check Point 24.5: (a) 2.5, (b) 3.5, (c) 1 wavelength, (d) yes

$$\frac{\Delta \ell}{\lambda} = \text{half integer} \qquad \text{[destructive]} \tag{24.4}$$

Check Point 24.6: (a) constructive, (b) destructive, (c) destructive, (d) constructive

25. Standing Waves

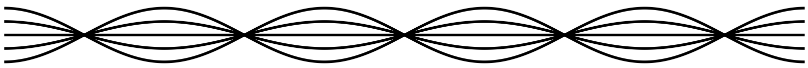
Check Point 25.1: Five

Check Point 25.2: 

Check Point 25.3: (a) The drawings should look similar to those in the textbook for a string fixed at both ends, (b) 132 cm, 66 cm, 44 cm, 33 cm

Check Point 25.4: (a) 132 cm, (b) 580.8 m/s, (c) 66 cm, (d) 580.8 m/s, (e) 880 Hz

Check Point 25.5: (a) 580.8 m/s, (b) 880 Hz, 1760 Hz, 2640 Hz, 3520 Hz, (c) 880 Hz, 1760 Hz, 2640 Hz, 3520 Hz

Check Point 25.6: 

Check Point 25.7: 36 cm

Check Point 25.8: Because at that moment the two pulses are superimposed on the same location and since one pulse is up and the other is down they interfere destructively

Check Point 25.9: 36 cm (the wavelength of the two traveling waves is the same as the wavelength of the resulting standing wave)

26. Light

Check Point 26.1: (a) No, (b) yes

Check Point 26.2: (a) true, (b) true, (c) true

Check Point 26.3: 6.8×10^{14} Hz

Check Point 26.4: (a) 0.24 s, (b) 2.1×10^5 s (almost two and a half days), (c) 0.24 s (the value in part a)

Check Point 26.5: (a) We can see the sun and stars, and the light from the sun and stars had to travel through the vacuum of space, (b) we can see light through a window.

$$n_{\text{material}} = \frac{c}{v_{\text{material}}} \tag{26.1}$$

Check Point 26.6: ethyl alcohol

Check Point 26.7: D

$$f_{\text{obs}} = f_{\text{emitted}} \frac{c + v_{\text{rel}}}{c} \qquad \text{if } v_{\text{rel}} \ll c \tag{26.2}$$

Check Point 26.8: Toward shorter wavelengths (v_{rel} is positive for motion toward the observer; since it is in the numerator the value increases)

27. Diffraction and Interference

Check Point 27.1: (a)

Check Point 27.2: Small differences in the lasers produce slightly different frequencies. Such small differences will be large compared to the period of the light (with red light, the period of the light wave is only 2×10^{-15} s). These small differences thus produce very high-frequency beating, preventing one from seeing a steady interference pattern.

Check Point 27.3: 880 nm

$$\frac{d \sin\theta}{\lambda} = \text{whole number} \qquad \text{[bright]} \tag{27.1}$$

$$\frac{d \sin\theta}{\lambda} = \text{half integer} \qquad \text{[dark]} \tag{27.2}$$

Check Point 27.4: 0.095°

Check Point 27.5: (a) The spacing remains the same, (b) the dots become fainter

$$\lambda = w \sin\theta. \tag{27.3}$$

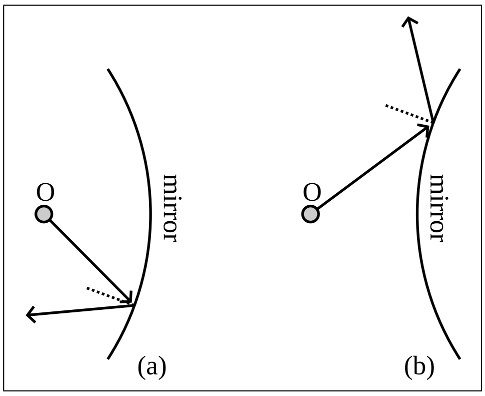
Check Point 27.6: As w gets larger, $\sin\theta$ needs to get smaller. That means that θ must likewise get smaller. If θ is smaller, the beam doesn't spread as much and the beam width gets closer to the slit width.

28. Reflection and Refraction

$$\theta_{\rm i} = \theta_{\rm r}. \tag{28.1}$$

Check Point 28.1: (a) 1 meter, (b) 75 cm

Check Point 28.2: The solution to each case is illustrated to the right.



Check Point 28.3: When the direction of a wave bends as it crosses the boundary between two materials (in which it travels at different speeds).

$$n_{\rm i} \sin\theta_{\rm i} = n_{\rm r} \sin\theta_{\rm r} \tag{28.2}$$

Check Point 28.4: (a) the index of refraction of the first material (that incident ray is located in) and the index of refraction of the second material (that the refracted ray is located in), (b) the angle at which the incident ray hits the interface (relative to the normal) and the angle at which the refracted ray leaves the interface (relative to the normal)

Check Point 28.5: 48.2°

Check Point 28.6: 50.3°

29. Objects and Images

Check Point 29.1: (a) 1 meter off the floor. (b) 75 cm off the floor, (c) the top 50 cm of the meter stick

Check Point 29.2: Your picture should look like the right part of the figure in the text.

Check Point 29.3: The image is on the right side of the mirror at point P. You should be able to draw the "extended rays" similar to the dotted lines in the figure.

Check Point 29.4: On the other side of the mirror (and closer to the mirror than the object distance)

Check Point 29.5: No. It would see the object, not the image. The light rays that the eye "sees" come from the object.

Check Point 29.6: Virtual

Check Point 29.7: Yes (give an example)

$$m = \frac{h_i}{h_o}. \tag{29.1}$$

Check Point 29.8: (a) the image, (b) inverted

Check Point 29.9: One cannot tell without knowing more information

Check Point 29.10: (a) The ray diagram should look like the figure, with the object (O) far away from the lens, the image (P) closer, the lens and then you.
(b) The image should be closer to you than the mountains and farther from you than the lens.

Check Point 29.11: The image would still be located where the screen used to be.

Check Point 29.12: A near-sighted person

30. Determining Image Size and Distance

Check Point 30.1: (a) Object distance is +20 cm and the image distance is −10 cm, (b) object distance is +20 cm and the image distance is +10 cm

Check Point 30.2: The image should be 0.6 m away (on the opposite side of the lens as the object).

Check Point 30.3: (a) At point P to the right of the lens, (b) because they never converge to a point (or appear to diverge from a point) since the source is so far away, (c) 20 cm from the lens

Check Point 30.4: Converging

Check Point 30.5: 5 diopters

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \tag{30.1}$$

Check Point 30.6: (a) 10 cm, (b) from the mirror

Check Point 30.7: (a) 3.01 cm, (b) 2.05 cm

Check Point 30.8: Infinitely far away

Check Point 30.9: The image of the mountains will be about 20 cm away from the lens (42 cm away from your eye) and will appear smaller than the mountains (as seen without the lens)

$$m = \frac{h_\mathrm{i}}{h_\mathrm{o}} = -\frac{d_\mathrm{i}}{d_\mathrm{o}}. \tag{30.2}$$

Check Point 30.10: (a) They would be equal, (b) yes

Check Point 30.11: The first lens produces a real image and real images are inverted. That image is then projected backwards (farther away) by the second lens so that our eyes can focus on it.