Example Questions for Quiz 3 – Solutions
(covering Chapters 3, 4 & 5)

Here are some questions that are similar to what will be on Quiz.
The quiz will have the 6 point question and others to make up 20 points.

1. (2 points) The swinging ball demonstration called Newton's Cradle demonstrates that the number of balls swinging out after the collision always matched the number of steel balls coming in. Conservation of momentum might allow two balls to go out at half the speed of a single ball coming in, but Nature insists that only one ball comes out with the same speed as the single incoming ball. **What other law** is needed to explain this?

The law of conservation of energy

2. (2 points) In an elastic collision where no energy is lost to heat, **what two laws of physics** are applicable?

Conservation of Momentum and Conservation of Energy

3. (2 points) **How much energy (work)** is required to raise a **weight** of 20 N by a height of 3 m against gravity at the surface of the earth?

$$W = F \cdot h = (20\,\mathrm{N}) \cdot (3\,\mathrm{m}) = 60\,\mathrm{N \cdot m} = 60\,\mathrm{J}$$

4. (3 points) **How much energy (work)** is required to raise a **mass** of 5 kg by a height of 2 m against gravity at the surface of the earth?

$$W = F \cdot h = m g h = (5\,\mathrm{kg}) \cdot (9.8\,\mathrm{m/s^2}) \cdot (2\,\mathrm{m}) = 98\,\frac{\mathrm{kg \cdot m^2}}{\mathrm{s^2}} = 98\,\mathrm{N \cdot m} = 98\,\mathrm{J}$$

5. (2 points) If a person does 10 MJ of work in 500 seconds, **how much power** is required?

$$P = \frac{W}{t} = \frac{10 \times 10^6\,\mathrm{J}}{500\,\mathrm{s}} = 20 \times 10^3\,\frac{\mathrm{J}}{\mathrm{s}} = 20 \times 10^3\,\mathrm{W} = 20\,\mathrm{kW}$$

6. (3 points) If a 50 kg person hikes up 3000 m in 5 hours, **how much power** is required using the unrealistic assumption that the person's muscles are 100% efficient?

$$P = \frac{W}{t} = \frac{m g h}{t} = \frac{(50\,\mathrm{kg}) \cdot (9.8\,\mathrm{m/s^2}) \cdot (3000\,\mathrm{m})}{(5\,\mathrm{h}) \cdot \left(\frac{3600\,\mathrm{s}}{1\,\mathrm{h}}\right)} = 81.7\,\frac{\mathrm{kg \cdot m^2}}{\mathrm{s^3}} = 81.7\,\frac{\mathrm{J}}{\mathrm{s}} = 81.7\,\mathrm{W}$$

7. (2 points) **How many calories** are in 100 J?

$$(100\,\mathrm{J}) \cdot \left(\frac{1\,\mathrm{cal}}{4.186\,\mathrm{J}}\right) = 23.89\,\mathrm{cal}$$

8. (2 points) **How many food calories** are in 100 J?

$$(100\,\mathrm{J}) \cdot \left(\frac{1\,\mathrm{cal}}{4.186\,\mathrm{J}}\right) \cdot \left(\frac{1\,\text{food calorie}}{1000\,\mathrm{cal}}\right) = 0.02389\,\text{food calorie}$$

9. (4 points) A person burns about 1500 food calories **per day**. **How much power** is the person generating from that food?

$$\frac{(1500\ \text{food calories})\cdot\left(\frac{1000\ \text{cal}}{1\ \text{food calorie}}\right)\cdot\left(\frac{4.186\ \text{J}}{1\ \text{cal}}\right)}{(1\ \text{day})\cdot\left(86400\frac{\text{s}}{\text{day}}\right)}=72.7\frac{\text{J}}{\text{s}}=72.7\ \text{W}$$

10. (2 points) A 2000 kg pickup truck is moving at 100 km/h. **How much kinetic energy** does it have?

$$KE=\frac{1}{2}mv^2=\frac{1}{2}(2000\ \text{kg})\cdot\left[\left(100\frac{\text{km}}{\text{h}}\right)\cdot\left(\frac{1000\ \text{m}}{1\ \text{km}}\right)\cdot\left(\frac{1\ \text{h}}{3600\ \text{s}}\right)\right]^2=7.72\times10^5\frac{\text{kg}\cdot\text{m}^2}{\text{s}^2}=7.72\times10^5\ \text{N}\cdot\text{m}=7.72\times10^5\ \text{J}$$

11. (2 points) If a 3 kg rock is dropped a height of 5 m, **how fast** is it moving when it hits the ground?

$$mgh=\frac{1}{2}mv^2 \quad \text{so} \quad v=\sqrt{2gh}=\sqrt{2\cdot(9.8\ \text{m/s}^2)\cdot(5\ \text{m})}=9.90\ \text{m/s}$$

(Note: This result is independent of the mass.)

12. (2 points) A temperature reading is -30 ºC, what is the **temperature in kelvin**?

$$T_K=T_C+273\ \text{K}=-30\ ^\circ\text{C}+273\ \text{K}=243\ \text{K}$$

13. (2 points) Liquid helium boils at 4.2 K, what is that **temperature on the Celsius scale**?

$$T_K=T_C+273\ \text{K} \quad \text{so} \quad T_C=T_K-273\ K=4.2\ \text{K}-273.0\ \text{K}=-268.8^\circ\text{C}$$

14. (6 points) Give the semi-joking phrases that describe the three laws of thermodynamics **and** briefly explain what that means:

1st: You can't win. – No machine can be devised to create new energy.
2nd: You can't even break even. – Perpetual motion machines cannot be built.
0th or 3rd: You must play the game – The universe is gradually becoming completely disorganized.

15. (2 points) **How many calories** are needed to melt 2 kg of ice at 0 ºC?

$$q=mL_f=(2000\ \text{g})\cdot\left(80\frac{\text{cal}}{\text{g}}\right)=160000\ \text{cal}=160\ \text{kcal}$$

16. (2 points) **How many calories** are needed to turn 4 kg of water to steam at 100 ºC?

$$q=mL_v=(4000\ \text{g})\cdot\left(540\frac{\text{cal}}{\text{g}}\right)=2160000\ \text{cal}=2160\ \text{kcal}$$

17. (2 points) **How many calories** are needed to heat 40 kg of water from 20 ºC to 50 ºC?

$$q=mc_{water}\Delta T=(40000\ \text{g})\cdot\left(1.00\frac{\text{cal}}{\text{g}\cdot^\circ\text{C}}\right)\cdot(50^\circ\text{C}-20^\circ\text{C})=1200000\ \text{cal}=1200\ \text{kcal}$$

18. (2 points) **How many calories** are needed to warm 300 g of ice from -50 ºC to -10 ºC?

$$q=mc_{ice}\Delta T=(300\ \text{g})\cdot\left(0.50\frac{\text{cal}}{\text{g}\cdot^\circ\text{C}}\right)\cdot[-10^\circ\text{C}-(-50^\circ\text{C})]=6000\ \text{cal}=6.00\ \text{kcal}$$

19. (2 points) **How many calories** are needed to heat 40 kg of steam from 100 ºC to 150 ºC?

$$q=mc_{steam}\Delta T=(40000\ \text{g})\cdot\left(0.48\frac{\text{cal}}{\text{g}\cdot^\circ\text{C}}\right)\cdot(150^\circ\text{C}-100^\circ\text{C})=9.60\times10^5\ \text{cal}=960000\ \text{cal}=960\ \text{kcal}$$

20. (2 points) An engine performs work in a cyclic process that takes in 1500 cal of heat at a higher temperature and exhausts 500 cal of heat to a lower temperature. **How much work** did it do?

$$W_{\text{out}} = Q_H - Q_L = 1500\,\text{cal} - 500\,\text{cal} = 1000\,\text{cal} = \left(4.186\,\frac{\text{J}}{\text{cal}}\right)\cdot\left(1000\,\text{cal}\right) = 4186\,\text{J}$$

21. (2 points) A refrigerator compressor doing work on a gas in a cyclic process that takes in 500 cal of heat at a lower temperature and exhausts 1500 cal of heat to a higher temperature. **How much work** must its compressor do?

$$W_{\text{in}} = Q_H - Q_L = 1500\,\text{cal} - 500\,\text{cal} = 1000\,\text{cal} = \left(4.186\,\frac{\text{J}}{\text{cal}}\right)\cdot\left(1000\,\text{cal}\right) = 4186\,\text{J}$$

22. (2 points) A **sound** wave (speed = 340 m/s) has a frequency of 5 kHz, **what is its wavelength**?

$$v = \lambda f \quad \text{so} \quad \lambda = \frac{v}{f} = \frac{340\,\text{m/s}}{5\times 10^3\,\text{Hz}} = \frac{340\,\text{m/s}}{5000\,\text{s}^{-1}} = 0.068\,\text{m}$$

23. (2 points) A wave has a **period** of 0.0002 s, **what is its frequency**?

$$T = \frac{1}{f} \quad \text{so} \quad f = \frac{1}{T} = \frac{1}{0.0002\,\text{s}} = \frac{1}{2\times 10^{-4}\,\text{s}} = 0.5\times 10^4\,\text{Hz} = 5\times 10^3\,\text{Hz} = 5000\,\text{Hz}$$

24. (2 points) Sound travels faster at (**higher**, ~~lower~~) temperatures. Circle the correct word.

Since $v_{T_p} = 331\,\text{m/s} + \left(0.600\,\frac{\text{m}}{\text{s}\cdot{}^{\circ}\text{C}}\right)\cdot T_p$ **, it is faster at higher temperatures.**

25. (2 points) If an instrument has a beat frequency of 4 Hz when compared with a 440 Hz tuning fork, its frequency is either __**444**__ Hz or __**436**__ Hz. It should be adjusted until the beat frequency is __**0**___Hz.

26. (2 points) The **intensity** of a sound is measured to be 10 W/m^2. **How much power** is received by a microphone with an **area** of 1 cm^2?

$$I = \frac{P}{A} \quad \text{so} \quad P = I\cdot A = \left(10\,\frac{\text{W}}{\text{m}^2}\right)\cdot\left(1\,\text{cm}^2\right)\cdot\left(\frac{1\,\text{m}}{100\,\text{cm}}\right)^2 = 0.001\,\text{W} = 10^{-3}\,\text{W} = 1\,\text{mW}$$

27. (2 points) A person twice as far from an explosion as another person receives (~~the same~~, ~~one-half~~, **one-forth**, ~~one-eight~~) the sound energy. Circle the correct answer.

28. (2 points) A child pumping a swing and a musician playing a stringed or wind instrument are all using the __**resonance**__ effect to generate large changes at specific frequencies from small stimuli.