

Physics 161 – Practise Third Exam
December 21, 2011 Prof. Steve Schnetzer

Your name sticker



with exam code

SOLUTIONS

1. The exam will last 180 minutes. Use a #2 pencil to make entries on the answer sheet. Enter the following id information now, before the exam starts.
2. In the section labelled NAME (Last, First, M.I.) enter your last name, then leave an empty circle (a blank), then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit Student ID Number.
4. Enter 161 under COURSE, and your section number under SEC.
5. Under CODE enter the exam code given above (very important).
6. During the exam, you may use a simple calculator. Presence of any other electronic device leads to confiscation of your exam and you will receive a zero grade.
- 7.
8. Before starting the exam, make sure that your copy contains all 30 questions: Raise your hand if this is not the case, and a proctor will help you. Also raise your hand during the exam if you have a question.
9. A proctor will check your name sticker and your student ID sometime during the exam. Please have them ready.
10. You are not allowed to give help to any other student, ask for help from anyone but a proctor, or change your seat without permission from a proctor. Doing so will result in a zero score for the exam.
11. Please hand in the mark sense form and the entire exam.
12. Please sign below to indicate that you have read and understood these instructions.

Constants

Gravity: $G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$

Avogadro: $N_A = 6.02 \times 10^{23} \text{ particles/mol}$

Boltzmann: $k_B = 1.38 \times 10^{-23} \frac{J}{K}$

gas constant $R = 8.31 \frac{J}{molK}$

Stefan-Boltzmann: $\sigma = 5.67 \times 10^{-8} \frac{W}{m^2K^4}$

Coulomb constant: $k_e = 8.99 \times 10^9 \frac{N \cdot m^2}{C^2}$

Speed of Light: $c = 3.00 \times 10^8 \frac{m}{s}$

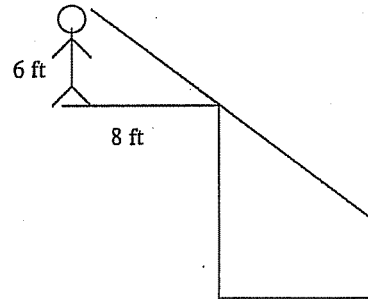
1. A six-foot chemist standing 8 ft to the side of an empty storage tank cannot see its bottom (top figure). As the tank is filled with a transparent liquid he first sees the bottom of the tank when the surface of the fluid is 3.46 ft above the bottom and his line-of-sight intersects the surface 2 ft from the far wall of the tank (bottom figure). The index of refraction of the liquid relative to air is:

- a) 1.33
- b) 2.0
- c) 1.4
- d) 1.8
- e) 1.6

$$n \sin \theta_2 = \sin \theta_1$$

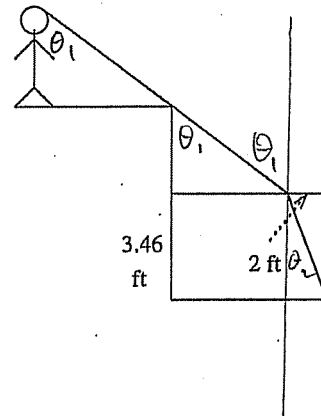
$$n \cdot 0.500 = 0.800$$

$$n = 1.6$$



$$\tan \theta_1 = \frac{8}{6} = 1.33$$

$$\sin \theta_1 = 0.800$$



$$\tan \theta_2 = \frac{2}{3.46} = 0.578$$

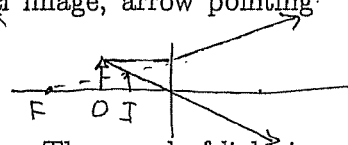
$$\sin \theta_2 = 0.500$$

2. A concave diverging lens with a focal length of 8.0 cm has an arrow pointing up placed on its axis 4.0 cm to the left of the lens. An image of the arrow would be formed on a screen placed at:

- a) 8.0 cm to the left of the lens with a ~~real~~ image, arrow pointing up
- b) 2.7 cm to the left of the lens with a ~~real~~ image, arrow pointing up
- c) 8.0 cm to the right of the lens with a ~~real~~ image, arrow pointing down
- d) 2.7 cm to the right of the lens with a ~~real~~ image, arrow pointing down

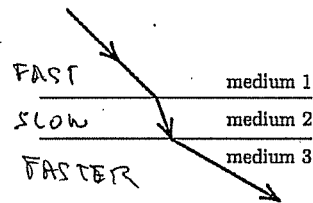
→ e) None of the other answers is correct

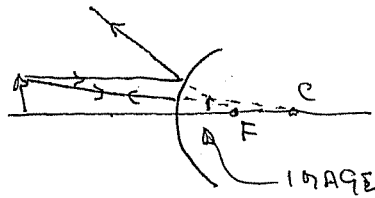
IMAGE IS VIRTUAL



3. A ray of light passes through three media as shown. The speed of light in these media obey:

- a) $v_1 > v_2 > v_3$
- b) $v_3 > v_2 > v_1$
- c) $v_3 > v_1 > v_2$
- d) $v_2 > v_1 > v_3$
- e) $v_1 > v_3 > v_2$





4. An erect object is in front of a convex mirror a distance greater than the focal length. The image is:

- a) ~~real~~, ~~inverted~~, and smaller than the object
- b) ~~virtual~~, ~~inverted~~, and larger than the object
- c) ~~real~~, ~~inverted~~, and larger than the object
- d) virtual, erect, and smaller than the object
- e) ~~real~~, erect, and larger than the object

5. An object sits 5cm from a lens and is 0.5 cm high. The lens forms a virtual image which is 1cm in size. What is the focal length of the lens? $f = ?$

- a) None of the other answers
- b) -3.3 cm (diverging)
- c) +1.25 cm (converging)
- d) -1.25 cm (diverging)
- e) +10 cm (converging)

$$p = 5$$

$$h = 0.5$$

$$q =$$

$$h' = 1.0$$

$$M = -\frac{q}{p} \text{ is POSITIVE} = \frac{h'}{h}$$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{5} + \frac{1}{10} = \frac{1}{f}$$

$$\frac{2}{10} + \frac{1}{10} = \frac{3}{10} = \frac{1}{f}$$

$$f = 10 \text{ cm}$$

$c_{Cu} = 387 \text{ J/kg}$ 6. 100 g of copper at 0°C is added to 100 g of water at 10°C . The temperature of the resultant mixture is

- a) 0°C
- b) 9.2°C
- c) 5°
- d) 1.1°
- e) 0.8°C

Cu

100 g

$T = 0^\circ\text{C} \rightarrow T_f$

$$Q = c_m \Delta T = 387 \cdot 0.1 (T_f - 0)$$

Water

100 g

$T = 10^\circ\text{C} \rightarrow T_f$

$$Q = c_w \Delta T$$

$$= 4186 \cdot 0.1 (10 - T_f)$$

$$387 T_f = 4186 (10 - T_f)$$

$$T_f = 9.16^\circ\text{C}$$

7. How much heat is needed to take ice of mass 360 g at -10°C to a liquid state at 15°C ? Specific heat of ice is $2220 \text{ J/kg} \cdot \text{K}$, specific heat of water is $4190 \text{ J/kg} \cdot \text{K}$, and the heat of fusion (melting heat) of ice is $3.33 \times 10^5 \text{ J/kg}$.

ice ($T = -10^\circ\text{C}$) \rightarrow water ($T = 15^\circ\text{C}$)

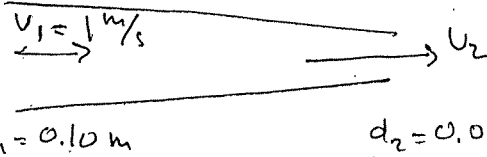
- a) 30 kJ
- b) 150 kJ
- c) 8 kJ
- d) 22 kJ
- e) 120 kJ

$$Q = m_{ice} c_{ice} \Delta T_{ice} + L_{ice} m_{ice} + m_{water} c_w \Delta T_w$$

$$= 0.36 [2220 \cdot 10 + 333000 + 4190 \cdot 15]$$

$$= 7992 + 119880 + 22626$$

$$Q = 150498 \text{ J}$$



$$\rho_{oil} = 800 \frac{kg}{m^3}$$

8. A pipe 0.10 m in diameter, narrowing smoothly to a diameter of 0.05 m, contains oil of density 800 kg/m³ flowing at a speed of 1.00 m/s in the large section of the pipe. What pressure difference would you expect between the large and small section of pipe? The oil flows horizontally and is incompressible.

$$v_1 \pi r_1^2 = v_2 \pi r_2^2$$

$$v_2 = v_1 \left(\frac{d_1}{d_2} \right)^2$$

$$v_2 = 1.0 \left(\frac{0.10}{0.05} \right)^2 = 4 \frac{m}{s}$$

a) 3000 Pa
 b) 6000 Pa
 c) 9000 Pa
 d) 12000 Pa
 e) 1500 Pa

$$P_1 + \frac{1}{2} \rho v_1^2 = P_2 + \frac{1}{2} \rho v_2^2$$

$$P_1 - P_2 = \frac{1}{2} \rho (v_2^2 - v_1^2)$$

$$= \frac{800}{2} (4^2 - 1^2) = \frac{800}{2} 15 = 6000 \text{ Pa}$$

9. A metal bar has a weight of 1 N in air and .93 N when completely immersed in water. What is the density of the bar? (density of water is 1000 kg/m³)

- a) 3.6 10³ kg/m³
 b) 8.4 10³ kg/m³
 c) 1.20 10⁴ kg/m³
 d) 1.32 10⁴ kg/m³
 e) 1.43 10⁴ kg/m³

$$mg = \rho V_{bar} g = 1.0$$

$$mg - B = 0.93$$

$$\rho V_{bar} g - \rho_{water} V_{bar} g = 0.93$$

$$\frac{\rho}{\rho - \rho_w} = \frac{1.0}{0.93} \Rightarrow 0.93 = 1 - \frac{\rho_w}{\rho}$$

10. Let E = total kinetic energy of the molecules of an ideal gas. Now suppose the gas is expanded so that the volume doubles while the pressure drops by a factor of 3. The new kinetic energy is

- a) 6E
 b) 3E/2
 c) E
 d) 2E/3
 e) E/6

$$U = E = \frac{3}{2} N k T = \frac{3}{2} k_I V_I$$

$$U_f = \frac{3}{2} P_f V_f = P_I V_I = \frac{2}{3} E$$

$$\frac{\rho_w}{\rho} = 0.07$$

$$\rho = \frac{1000}{0.07} = 14285 \frac{kg}{m^3}$$

11. The 0.5 moles of an ideal monoatomic gas in the cylinder of an engine expands rapidly and adiabatically against a piston. In the process, the temperature drops from 1250 K to 500 K. How much work did the gas do?

- a) 3.3 kJ
 b) -3.3 kJ
 c) 4.7 kJ
 d) -4.7 kJ
 e) 2.3 kJ

$$n = 0.5 \text{ adiabatic} \Rightarrow Q = 0$$

$$U_i = \frac{3}{2} n R T_i = \frac{3}{2} 0.5 8.31 1250 = 7791 \text{ J}$$

$$U_f = \frac{3}{2} 0.5 8.31 500 = 3116 \text{ J}$$

$$U_i + Q + W^{on} = U_f$$

$$7791 + 0 + W^{on} = 3116$$

$$W^{on} = -4675 \text{ J}$$

$$W^{by} = +4675 \text{ J}$$

12. Two ideal monoatomic gases at the same temperature but in different containers must have the same

- a) number of molecules
- b) pressure
- c) average kinetic energy per molecule
- d) volume
- e) product of volume and pressure

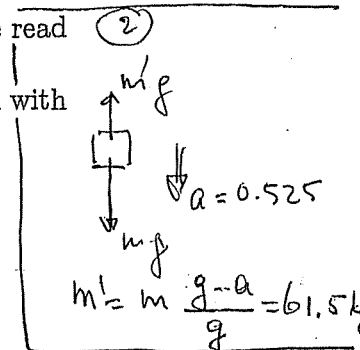
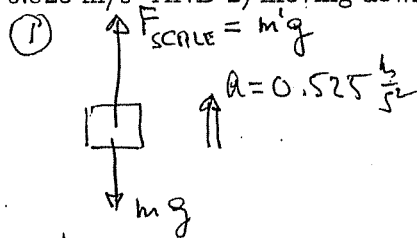
$$\overline{KE} = \frac{1}{2} m \overline{v^2} = \frac{3}{2} kT$$

Same T \rightarrow same \overline{KE}
Same $\overline{v^2}$

13. A 65 kg person stands on a scale in an elevator. What does the scale read if the elevator is

- 1) moving up with an acceleration of 0.525 m/s² AND 2) moving down with an acceleration of 0.525 m/s²?
(g = 9.8 m/s²)

- a) 1) 68.5 kg AND 2) 61.5 kg
- b) 1) 61.5 kg AND 2) 68.5 kg
- c) 1) 72.6 kg AND 2) 63.4 kg
- d) 1) 63.4 kg AND 2) 72.6 kg
- e) 1) 65.0 kg AND 2) 65.0 kg



$$m'g - mg = ma$$

$$m' = m \frac{g+a}{g} = 65 \frac{10.325}{9.8} = 68.48$$

14. Two blocks, weighing 250 N and 350 N, respectively, are connected by a string that passes over a massless pulley as shown. The tension in the string is:

- a) 210 N
- b) 290 N
- c) 410 N
- d) 500 N
- e) 4900 N

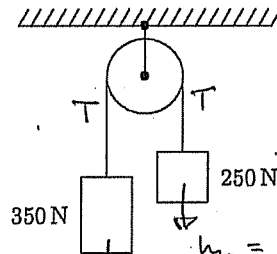
350 N:
350 - T = 35.71 a

250 N:
T - 250 = 25.51 a

$$100 = 61.22 a$$

$$a = 1.63 \text{ m/s}^2$$

$$T = 250 + 25.51 \cdot 1.63 = 292 \text{ N}$$

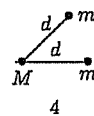
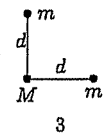
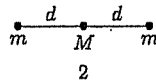
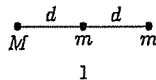
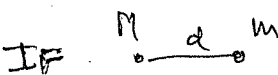


$$m_2 = \frac{250}{9.8} = 25.51$$

$$m_1 = \frac{350}{9.8} = 35.71$$

15. Three particles, two with mass m and one with mass M , might be arranged in any of the four configurations shown below. Rank the configurations according to the magnitude of the gravitational force on M , least to greatest.

- a) 1,2,3,4
- b) 2,1,3,4
- c) 2,1,4,3
- d) 2,3,4,2
- e) 2,3,1,4



$$F_0 = G \frac{mM}{d^2}$$

$$F_0 + \frac{1}{4} F_0$$

$$F_0 \cdot 1.25$$

$$0$$

$$F_0 \sqrt{2}$$

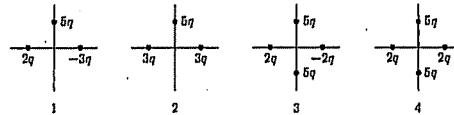
$$F_0 \cdot 1.41$$

SMALLEST
 LARGEST

① < ③

16. The diagrams below depict four different charge distributions. The charge particles are all the same distance from the origin. The electric field at the origin:

- a) is greatest for situation 1
- b) is greatest for situation 3
- c) is zero for situation 4
- d) is downward for situation 1
- e) is downward for situation 3



17. A positive charge of $4e$ ($e =$ magnitude of charge on electron) is moved by hand slowly (no change in kinetic energy) from point A at a potential of $+9V$, to point B at a potential of $+45V$, and finally to point C at a potential of $-20V$. What is the net work done on the charge by the hand?

- a) $+5.4 \times 10^{-18} J$
- b) $-7.0 \times 10^{-18} J$
- c) $+7.0 \times 10^{-18} J$
- d) $-18.6 \times 10^{-18} J$
- e) $-5.4 \times 10^{-18} J$

$+9V \quad +45V \quad -20V$

W NEGATIVE

$W = q \Delta V$
 $= -41.6 \times 10^{-19} J$

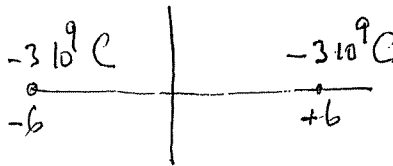
18. What would be the capacitance required to store an energy of 1 kW-hour, when the potential difference between the plates of the capacitor is 100V?

- a) 360F
- b) 720F
- c) 300F
- d) 460F
- e) 100F

1 kW-hour = 1000 * 3600 Joules = $3.6 \times 10^6 J = \frac{1}{2} C V^2 = \frac{1}{2} C 10^4 \Rightarrow C = 7.2 \times 10^2 F$

19. A charge of $-3.0 nC$ lies on the x-axis at $x = +6 cm$, and another equal charge of $-3.0 nC$ is at $x = -6 cm$. The magnitude of the electric field at the origin is

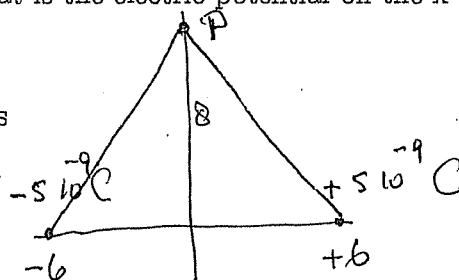
- a) Zero
- b) 7500 N/C
- c) 15000 N/C
- d) 450 N/C
- e) 900 N/C



opposite E fields
 at origin: CANCEL
 \Rightarrow ZERO

20. A charge of $+5 nC$ is on the y-axis at $y = +6 cm$, and a charge of $-5 nC$ is on the y-axis at $y = -6 cm$. What is the electric potential on the x-axis at the point $x = 8 cm$?

- a) 450 V
- b) None of the other answers
- c) 540 V
- d) 9000 V
- e) 900 V

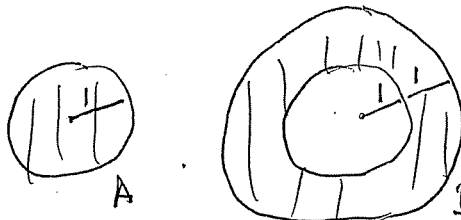


POTENTIAL AT P:
 2 EQUAL + OPPOSITE CONTRIBUTIONS

$\Rightarrow V = 0$
 at P

21. Two conductors are made of the same material and have the same length. Conductor A is a solid wire of diameter 1 m. Conductor B is a hollow tube of inside diameter 1 m and outside diameter 2 m. The ratio of their resistance, R_A/R_B , is:

- a) 1
 b) $\sqrt{2}$
 c) 2
 — d) 3
 e) 4



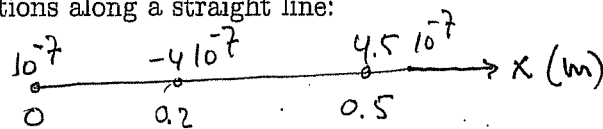
same ρ , L

$$R = \rho \frac{L}{\text{AREA}}$$

$$\frac{R_A}{R_B} = \frac{\text{AREA}_B}{\text{AREA}_A} = \frac{2^2 - 1^2}{1^2} = 3$$

22. Three charges are located at the following positions along a straight line:

- $q_1 = +10^{-7}$ C at $x = 0$
- $q_2 = -4 \times 10^{-7}$ C at $x = 0.2$ m
- $q_3 = +4.5 \times 10^{-7}$ C at $x = 0.5$ m



What is the net force (magnitude and direction) on q_2 ?

- a) 9.0×10^{-3} N; to the left
 — b) 9.0×10^{-3} N; to the right
 c) 18.0×10^{-3} N; to the right
 d) 18.0×10^{-3} N; to the left
 e) 27.0×10^{-3} N; to the left

$$q_2 E_1 = \frac{9 \cdot 10^{-7} \cdot 10^{-7}}{0.2^2} \text{ TO LEFT}$$

$$q_2 E_3 = \frac{9 \cdot 10^{-7} \cdot 4.5 \cdot 10^{-7}}{0.3^2} \text{ TO RIGHT}$$

$$q_2 E_1 = 900 \cdot 10^{-5}$$

$$q_2 E_3 = 1800 \cdot 10^{-5}$$

$$F_{\text{NET}} = 900 \cdot 10^{-5} \text{ N TO RIGHT}$$

23. A 4.0 N puck is traveling at 3.0 m/s. It strikes a 8.0 N puck, which is stationary. The two pucks stick together. Their common final speed is:

- a) 1.0 m/s
 b) 1.5 m/s
 c) 2.0 m/s
 d) 2.3 m/s
 e) 3.0 /s

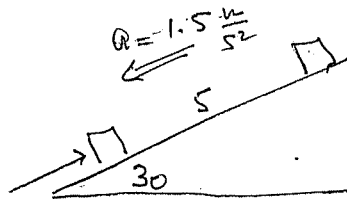
$$v_1 = 3 \text{ m/s} \quad m_1 g = 4 \text{ N} \quad \left. \begin{array}{l} v_1 m_1 + v_2 m_2 \\ v_2 = 0 \quad m_2 g = 8 \text{ N} \end{array} \right\} g = 12$$

Final: $V (m_1 + m_2) g = 12$

$$V = \frac{12}{4+8} = 1 \text{ m/s}$$

24. All of the following are false, except:

- a) In an elastic collision, momentum is conserved but ~~some heat may be produced.~~
- b) In an inelastic collision, the total energy is conserved ~~but momentum is not.~~
- c) In an elastic collision momentum and mechanical energy are conserved.
- d) In an inelastic collision, momentum and mechanical energy are conserved.
- e) in a collision between two macroscopic objects, there is always a loss of at least a small amount of total momentum.



$$v_F^2 - v_I^2 = 2ax = -2(1.5)5 = -15 \left(\frac{m^2}{s^2} \right)$$

Note \vec{a} AND \vec{v} ARE ANTI PARALLEL

25. A man pushes an 80 N crate a distance of 5.0 m upward along a frictionless slope that makes an angle of 30° with the horizontal. His force is parallel to the slope. If the speed of the crate decreases at a rate of 1.5 m/s^2 , then the work done by the man is:

a) -200 J $KE_I + PE_I + W = KE_F + PE_F$

b) 61 J $W = KE_F - KE_I + PE_F - PE_I$

c) 140 J

d) 200 J

e) 260 J

$$= \frac{1}{2} m(v_F^2 - v_I^2) + mg(h_F - h_I)$$

$$= -\frac{80}{2 \cdot 9.8} 15 + 80 \cdot 5 \sin 30^\circ = -61.2 + 200 = +138.8 \text{ J}$$

26. A 3.0 kg block starts from rest and slides down a plane that is inclined to the horizontal at an angle of 30 degrees. Assuming no friction, what is its speed after it has slid 4.0 m along the plane?

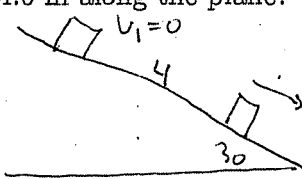
a) 8.9 m/s

b) 6.0 m/s

c) 6.3 m/s

d) 12 m/s

e) 18 m/s



$m = 3 \text{ kg}$

$$\frac{1}{2} m v_1^2 + PE_1 = \frac{1}{2} m v_2^2 + PE_2$$

$$0 + mg \frac{4}{2} = \frac{1}{2} m v_2^2 + 0$$

$$\frac{1}{2} 8g = v_2^2 \Rightarrow v_2^2 = 39.2$$

$$v_2 = 6.26 \frac{m}{s}$$

27. A ball is tossed from the window of a building. The ball is given an initial velocity of 8.0 m/s at an angle of 20° below the horizontal. It strikes the ground 3.0 s later. How far horizontally from the base of the building does the ball strike the ground?



a) 8.2 m

b) 24 m

c) 67 m

d) 23 m

e) 44 m

$$v_x = v \cos 20 = 8 \cdot 0.9397 = 7.517 \frac{m}{s}$$

$$x = v_x t = 7.517 \cdot 3 = 22.55 \text{ m}$$

28. A piano wire has length L and mass M . If its fundamental frequency is f , its tension is:

a) $2Lf/M$

b) $4MLf$

c) $2MLf^2/L$

d) $4f^2L^3/M$

e) $4LMf^2$

$$\mu = \frac{M}{L} \quad T = \text{tension}$$

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{TL}{M}}$$

$$v = \lambda f$$

FOR FUNDAMENTAL $\lambda = 2L$

$$\text{Now } 2Lf = \sqrt{\frac{TL}{M}}$$

$$\text{or } \frac{TL}{M} = 4L^2f^2 \Rightarrow \boxed{T = 4LMf^2}$$

$$v = \lambda f$$

$$v^2 = \frac{T}{\mu}$$

29. A guitar string vibrates at 1320 Hz. If the string tension is increased by 2%, what will be the new frequency for the same harmonic?

- a) 1294 Hz
- b) 1307 Hz
- c) 1320 Hz
- d) 1333 Hz
- e) 1346 Hz

same λ, μ

$$f_1 = 1320 \text{ Hz}$$

$$f_2 = ?$$

$$T_1$$

$$T_2 = 1.02 T_1$$

$$v_1$$

$$v_2$$

$$\begin{aligned} v_2^2 &= 1.02 v_1^2 \\ v_2 &= 1.01 v_1 \\ \lambda f_2 &= 1.01 \lambda f_1 \\ f_2 &= 1.01 f_1 \\ &= 1333 \text{ Hz} \end{aligned}$$

30. The half-life of radium is about 1600 years. If a rock initially contains 1 g of radium, the amount left after 6400 years will be about:

- a) 938 mg
- b) 62 mg
- c) 31 mg
- d) 16 mg
- e) less than 16 mg

$$T_{1/2} = 1600 \text{ year}$$

$$t = 6400 = n T_{1/2} \Rightarrow n = 4$$

$$e^{-\lambda t} = \left(\frac{1}{2}\right)^4 = \left(\frac{1}{2}\right)^4 = \frac{1}{16}$$

$$N = N_0 \frac{1}{16} = 1 \frac{1}{16} = 0.0625 \text{ gram}$$