# PHYS 117 2021 Final Exam Solutions – Regular

## Description

This set of 1 statement of commitment to academic integrity and 16 questions is the final exam for PHYS 117 Winter 2021 at the University of Saskatchewan.

For each of the 10 multiple-choice questions, submitted through WebAssign, the answer(s) are worth 1 mark, for a total of 10 marks. All 10 multiple-choice questions are weighted equally.

For each of the 6 word problems, the answer(s) (submitted through WebAssign) are worth 1 mark and the solutions (submitted through Canvas) are worth 3 marks, for a total of 24 marks. All 6 word problems are weighted equally.

The exam is worth a total of 34 marks.

## Instructions

Answers for **all** questions need to be submitted in WebAssign.

For each of questions 12 through 17, in addition to submitting your answers in WebAssign, write the complete solution, **including a diagram, as noted**, using the problem-solving method discussed in class.

***Your solutions must use the same symbols as are used on the formulae sheet.***

***Formulas not on the Formulae Sheet must be derived.***

**Keep extra decimal places throughout your calculations, and then round-off your final answer to three significant figures.**

Submit your answer to each question in WebAssign.

When you have finished the entire exam, scan your written work for questions 12 through 17 and submit a single multi-page PDF file using the link in the Canvas site for your section.

**Your WebAssign submission is due no later than three hours (180 minutes) after the questions become available and your Canvas submission is due no later than three-and-a-half hours (210 minutes) after the questions become available. LATE SUBMISSIONS WILL NOT BE ACCEPTED.**

1. - UofS-P115-P117-Honour [4820285]
On my honour, I pledge that I will not give or receive aid during this assessment. I understand that I am expected to complete this assessment with no communication with other persons and no resource material other than the PHYS 115/117 Formulae sheet. I recognize that it is my responsibility to uphold academic integrity and I agree to follow the rules of this assessment and the guidelines laid forth in the policies of the University of Saskatchewan. Furthermore, I fully understand that disciplinary action may be taken against me if I am discovered to have communicated with another person or to have used an internet resource.

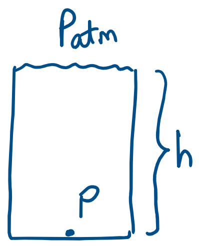
Yes, I understand and agree.

2. - P117-2021-Final-Q1-Reg [4975813]

When a container is completely filled with water ($\rho$ = 1000 kg/m$^3$), the pressure at the bottom of the container is $P$. The water is poured out and the container is filled with mercury ($\rho$ = 13.6 × 10$^3$ kg/m$^3$). The pressure at the bottom of the glass is now which of the following?

(A) indeterminate (B) larger than $P$ (correct) (C) smaller than $P$ (D) equal to $P$

10:11




$P = P_{atm} + \rho g h$ ← $\rho$: density of liquid.

since $\rho_{Hg} > \rho_{H_2O}$, $P_{Hg} > P$

3. - P117-2021-Final-Q2-Reg [4975818]

The length of a pendulum is increased by a factor of 4 and the mass of the pendulum bob is decreased to half of the original mass. Which one of the following statements concerning the new period $T_N$ compared to the old period $T$ is correct?

(A) $T_N = T$ (B) $T_N = 8\ T$ (C) $T_N = 2\ T$ (correct) (D) $T_N = T \div 1.41$ (E) $T_N = 1.41\ T$

10:13

$T = 2\pi\sqrt{\frac{L}{g}}$ , no mass dependence

$L_N = 4L$ $\quad T_N = 2\pi\sqrt{\frac{L_N}{g}} = 2\pi\sqrt{\frac{4L}{g}} = 2\pi\, 2\sqrt{\frac{L}{g}} = 2T$

4. - P117-2021-Final-Q3-Reg [4975824]

A transverse wave with a wavelength of 0.450 m is traveling on a horizonal string by causing the segments of the string to oscillate in simple harmonic motion as described by

$y$ = (5.25 cm) cos(1.80$\pi$t)

where $y$ is the vertical position of a segment from the equilibrium position and $t$ is the time in seconds. Which one of the following options is the correct value of the propagation speed of this wave?

(A) 1.27 m/s (B) 0.0236 m/s (C) 0.0945 m/s (D) 0.405 m/s (correct) (E) 0.810 m/s

10:14 $\quad y = (5.25\text{ cm})\cos(1.80\pi t)$

compare with $x = A\cos(2\pi f t)$

$A = 5.25\text{cm}$ ; $2\pi f = 1.80\pi \Rightarrow 2f = 1.80 \Rightarrow f = 0.90\text{ Hz}$

$v = f\lambda = (0.90\text{ Hz})(0.450\text{m}) = \boxed{0.405\text{ m/s}}$

5. - P117-2021-Final-Q4-Reg [4975831]
Which one of the following statements concerning electromagnetic waves is **FALSE**?

(A) The wavelength of an electromagnetic wave in a vacuum is different for different wave frequencies. T
(B) The propagation speed of an electromagnetic wave in a vacuum is different for different wave frequencies. (correct answer) F
(C) The electric field oscillates perpendicular to the direction of propagation of the wave. T
(D) The magnetic field oscillates perpendicular to the direction of propagation of the wave. T
(E) The electric and magnetic fields are perpendicular to each other. T

10:19

6. - P117-2021-Final-Q5-Reg [4975832]
Monochromatic light of wavelength 585 nm is diffracted by a single-slit with a width of 0.380 mm and the diffraction pattern forms on a screen that is 1.90 m away from the slit. What is the width of the central maximum? You may assume that the small angle approximation is valid.

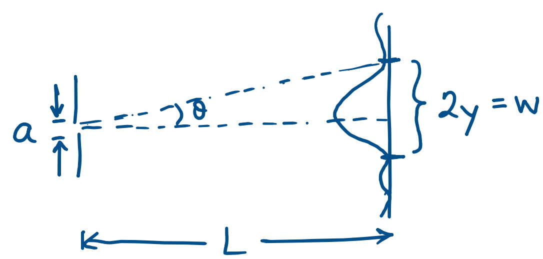
(A) 0.00585 mm (B) 0.00293 mm (C) 5.85 mm (D) 2.93 mm (E) 0.00810 mm

10:20

$\lambda = 585\text{ nm}$

$a = 0.380\text{ mm}$

$L = 1.90\text{ m}$




Single-slit Diffraction

Location of 1st minimum: $\sin\theta_{dark} = m\frac{\lambda}{a}$ ; $m = 1$

$\sin\theta_{dark} = \frac{\lambda}{a} \Rightarrow \theta_{dark} = \frac{\lambda}{a}$ using small angle approx.

$\tan\theta_{dark} = \theta_{dark} = \frac{y}{L}$ using small angle approx.

$\therefore \frac{y}{L} = \frac{\lambda}{a} \Rightarrow y = \frac{\lambda L}{a} \Rightarrow w = 2y = \frac{2\lambda L}{a}$

$$w = \frac{2(585\times10^{-9}\text{ m})(1.90\text{ m})}{0.380\times10^{-3}\text{ m}} = 5.85\times10^{-3}\text{ m} = \boxed{5.85\text{ mm}}$$

7. - P117-2021-Final-Q6-Reg [4975834]

A particular star has a radius of $8.64 \times 10^8$ m. The peak intensity of the radiation it emits is at a wavelength of 688 nm. Which set of values is correct for the energy, *E*, (in J), of a photon with this wavelength and the star's surface temperature, *T* (in K)? Express the temperature to the nearest integer.

(A) E = 1.80 J; T = 4212 K
(B) E = $2.89 \times 10^{-19}$ J; T = 4212 K (correct)
(C) E = $2.89 \times 10^{-19}$ J; T = 3939 K
(D) E = $1.13 \times 10^{19}$ J; T = 3939 K
(E) E = 2.89 J; T = 6880 K

10:25 $R = 8.64 \times 10^8\,m$ $\lambda_{max} = 688\,nm$

$$E_{photon} = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\,J\cdot s)(2.998\times10^8\,m/s)}{688\times10^{-9}\,m} = 2.89\times10^{-19}\,J$$

$$\lambda_{max} T = 2.898\times10^{-3}\,m\cdot K$$

$$T = \frac{2.898\times10^{-3}\,m\cdot K}{688\times10^{-9}\,m} = 4212\,K$$

8. - P117-2021-Final-Q7-Reg [4975836]

Lead has characteristic x-ray lines at energies of 74.3 keV and 10.5 keV. If a lead sample is illuminated with x-rays from an x-ray tube operating at 65 kV, which one of the following statements is correct regarding which of the characteristic lines will appear in the spectrum of x-rays emitted by the lead sample?

(A) Both the 74.3 keV and 10.5 keV lines will be observed.
(B) Only the 74.3 keV line will be observed.
(C) Neither of the lines will be observed.
(D) Only the 10.5 keV line will be observed. (correct)

10:29 In order for a particular characteristic line to be present, $E_{max_{x\text{-}ray}}$ must be greater than the energy of the line.

$E_{max_{x\text{-}ray}} = eV_A = 65\,keV$, which is $< 74.3\,keV$

$\therefore$ Only the 10.5 keV line will be present.

9. - P117-2021-Final-Q8-Reg [4975838]
A hydrogen atom undergoes a transition from the $n = 7$ state to the $n = 4$ state. What is the energy of the emitted photon?

(A) 0.278 eV (B) 0.573 eV (correct) (C) 0.850 eV (D) 1.18 MeV (E) 1.46 eV

10:33

$$E_\gamma = E_7 - E_4 = -13.6\,\text{eV}\left(\frac{1}{7^2} - \frac{1}{4^2}\right) = 0.572\,\text{eV}$$

10. - P117-2021-Final-Q9-Reg [4975846]
In the following reaction, identify the atomic number (Z) and mass number (A) of the unidentified product.

$${}^{238}_{92}U + {}^{1}_{0}n \rightarrow {}^{140}_{56}Ba + {}^{A}_{Z}X + 2\,{}^{1}_{0}n$$

(A) Z = 35; A = 96 (B) Z = 36; A = 98 (C) Z = 35; A = 97 (D) Z = 36; A = 97 (correct)
(E) Z = 36; A = 96

10:33

A: $238 + 1 = 140 + A + 2(1)$

$239 = 142 + A \Rightarrow A = 239 - 142 = 97$

Z: $92 = 56 + Z \Rightarrow Z = 92 - 56 = 36$

11. - P117-2021-Final-Q10-Reg [4975847]
To sterilize a 100-g glass bottle, we must raise its temperature from 19.5°C to 95.0°C. How much energy must be transferred to the bottle as heat? The specific heat of glass is 840 J/(kg·°C).

(A) 7980 J (B) 1640000 J (C) 6340 J (correct) (D) 1640 J (E) 6340000 J

$m = 100\ \text{g} = 0.100\ \text{kg}$

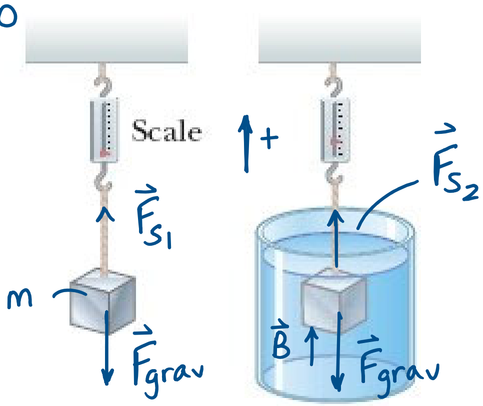
$\Delta T = 95.0°C - 19.5°C = 75.5\ C°$

$$\Delta E = mc\Delta T = (0.100\ \text{kg})\left(\frac{840\ \text{J}}{\text{kg}\cdot°\text{C}}\right)(75.5\ C°) = 6.34\times10^{3}\ \text{J}$$

10:39

12. - P117-2021-Final-Q12-Reg [4975907]
An object suspended from a spring scale in air causes the scale to read a value of 5.50 N. When the suspended object is submerged in water the spring scale now reads 3.16 N. Calculate the density (in kg/m$^3$) of the object. **A diagram is required as part of your solution.**

10:40




Object is in equilibrium: $\Sigma \vec{F} = 0$

$$+F_{s_1} - F_{grav} = 0 \Rightarrow F_{grav} = mg = F_{s_1} = 5.50\text{N}$$

$$+F_{s_2} + B - F_{grav} = 0 \Rightarrow B = F_{grav} - F_{s_2}$$

$$B = 5.50\text{N} - 3.16\text{N}$$

$$B = 2.34\text{N}$$

At the left, the figure shows a vertical spring scale. The top of the scale has a hook attached to the ceiling. The bottom of the scale has a hook attached to a rope. The rope hangs down and is attached to the object that hangs from the rope. At the right, the figure shows the same scale, but now the object is submerged in a tank of water. The reading on the scale at the right is less than the reading on the scale at the left. 2350 kg/m$^3$

$$B = \rho_{fluid} V_{fluid}\, g \quad \text{and} \quad V_{fluid} = V_{object}$$

$$\therefore \quad V_{object} = \frac{B}{\rho_{fluid}\, g}$$

$$\rho_{object} = \frac{m_{obj}}{V_{object}} = \frac{F_{grav}/g}{B/\rho_{fluid}\, g} = \frac{F_{grav} \cdot \rho_{fluid}}{B}$$

$$\rho_{object} = \frac{(5.50\text{ N})(1.00 \times 10^3 \text{ kg/m}^3)}{2.34\text{N}} = \boxed{2.35 \times 10^3 \text{ kg/m}^3}$$

10:46

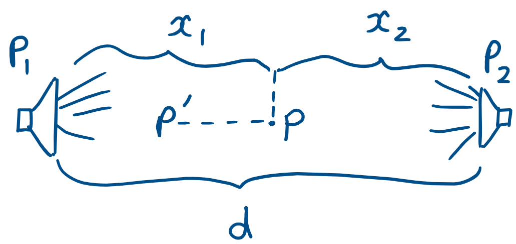
6 minutes

13. - P117-2021-Final-Q13-Reg [4975910]
Two speakers are placed 29.8 m apart, and are facing each other. Each speaker has a power output of 0.370 W and is broadcasting an amplified static buzz uniformly in all directions. **A diagram is required as part of your solution.**

(a) Calculate the total sound intensity a person hears when they are midway between the speakers.
0.000265 W/m$^2$

(b) Calculate the total sound intensity the person hears after they move directly toward one of the speakers for a distance of 7.7 m. 0.000626 W/m$^2$

10:49




$P_1 = P_2 = 0.370\,W$

(a) $x_1 = x_2 = \frac{1}{2}d = \frac{1}{2}(29.8m) = 14.9m$

$$I_p = \frac{P_1}{4\pi x_1^2} + \frac{P_2}{4\pi x_2^2} = 2\frac{P_1}{4\pi x_1^2} = \frac{P_1}{2\pi x_1^2}$$

$$I_p = \frac{0.370\,W}{2\pi(14.9m)^2} = \boxed{2.65\times10^{-4}\,W/m^2}$$

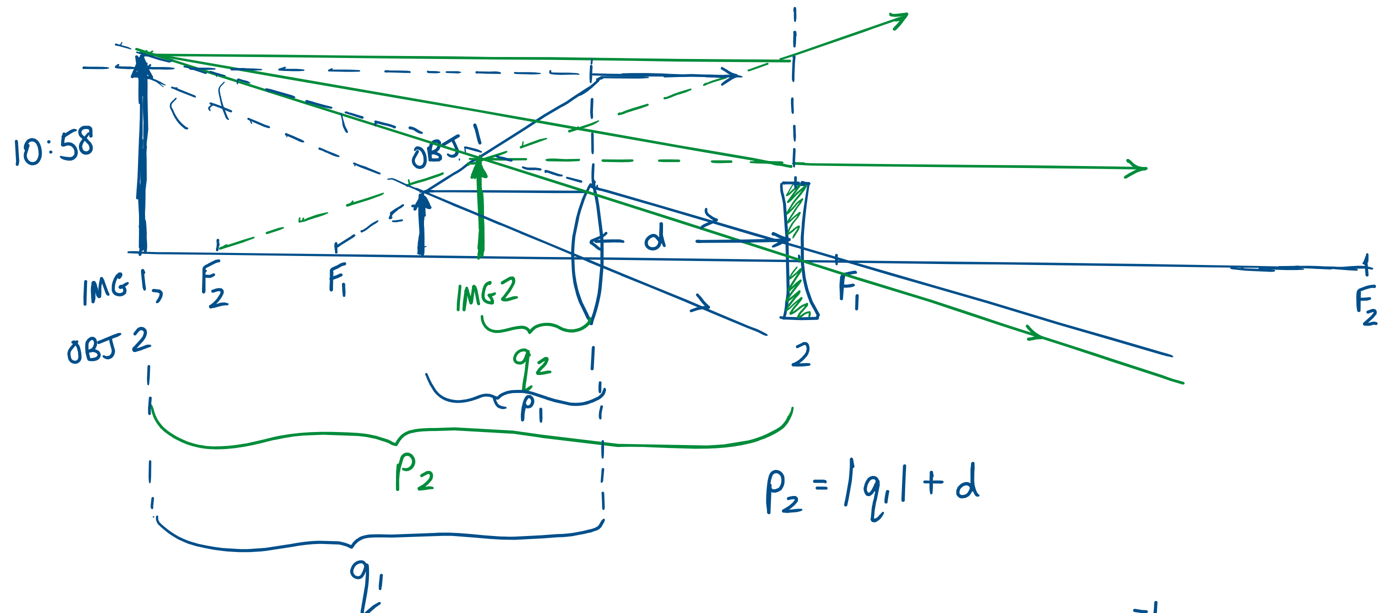
(b) $x_1' = 14.9m - 7.7m = 7.2m$ ; $x_2' = 14.9m + 7.7m = 22.6m$

$$I_{p'} = \frac{0.370\,W}{4\pi}\left(\frac{1}{x_1'^2} + \frac{1}{x_2'^2}\right) = \boxed{6.26\times10^{-4}\,W/m^2}$$

10:56

7 minutes

14. - P117-2021-Final-Q14-Reg [4975914]
A diverging lens with a focal length of −16.00 cm is placed 6.00 cm to the right of a converging lens with a focal length of 7.00 cm. A 1.00-cm-high object is placed 4.50 cm to the left of the converging lens. Calculate the position (including sign) and height of the final image. **A complete ray diagram is required.**
ANS: $q_2$ = -8.6 cm and the final image (which is upright and virtual) is in front of the second lens




$$\frac{1}{f_1} = \frac{1}{p} + \frac{1}{q_1} \Rightarrow q_1 = \left(\frac{1}{f_1} - \frac{1}{p_1}\right)^{-1} = \left(\frac{1}{7.00\text{cm}} - \frac{1}{4.50\text{cm}}\right)^{-1} = -12.6\text{cm}$$

$$p_2 = 12.6\text{cm} + 6.00\text{cm} = 18.6\text{ cm}$$

$$\frac{1}{f_2} = \frac{1}{p_2} + \frac{1}{q_2} \Rightarrow q_2 = \left(\frac{1}{f_2} - \frac{1}{p_2}\right)^{-1} = \left(\frac{1}{-16.0\text{cm}} - \frac{1}{18.6\text{cm}}\right)^{-1} = -8.60\text{cm}$$

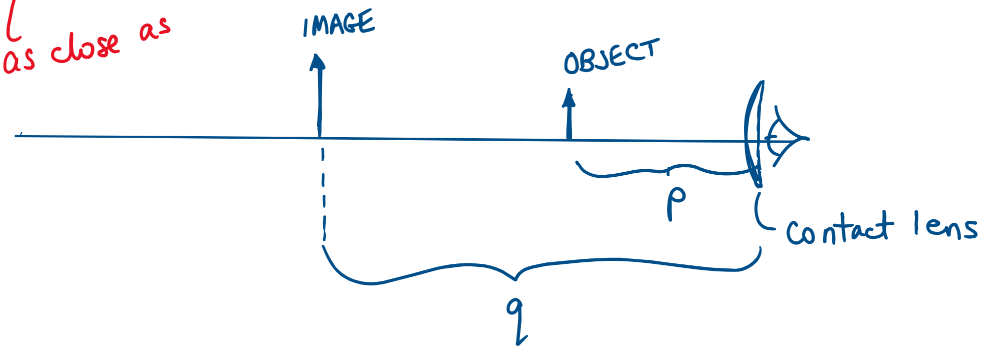
Final image is upright and virtual as shown in the ray diagram.

11:11
13 minutes

15. - P117-2021-Final-Q15-Reg [4975915]
An examination reveals that a patient has a near point of 55.0 cm. The patient needs to be able to clearly see objects that are 24.0 cm from the eye. A contact lens is prescribed. Calculate the necessary power, *P*, in diopters, including sign, of the contact lens. Assume that the lens can be modelled as an ideal thin lens, which lies adjacent to the eye. **A diagram showing the object, image, and contact lens is required.**
2.35 diopters

* as close as

11:13




$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow P = \frac{1}{p} + \frac{1}{q} = \frac{1}{0.240\,m} + \frac{1}{(-0.550\,m)} = +2.35 \text{ diopters}$$

11:17
4 minutes

16. - P117-2021-Final-Q16-Reg [4975922]
A sample of a certain radioactive isotope has an initial activity of 10.0 kBq. 4.30 h later, the activity is 8.40 kBq. **A diagram is NOT required.**

(a) Calculate the decay constant and the half-life of the isotope. $\lambda = 0.0405\ h^{-1}$ ; $T_{1/2} = 17.1$ h

(b) Calculate the sample's activity 30.0 h after it was prepared. 2.96 kBq

11:18

(a) $R = R_0 e^{-\lambda t} \Rightarrow \frac{R}{R_0} = e^{-\lambda t} \Rightarrow \ln\left(\frac{R}{R_0}\right) = -\lambda t$

$$\lambda = \frac{-\ln(R/R_0)}{t} = \frac{-\ln\left(\frac{8.40\ kBq}{10.0\ kBq}\right)}{4.30\ h} = 0.04055\ h^{-1} = \boxed{0.0405\ h^{-1}}$$

$$T_{1/2} = \frac{\ln 2}{\lambda} = 17.09\ h = \boxed{17.1\ h}$$

(b) $R = R_0 e^{-\lambda t} = 10.0\ kBq\ e^{-(0.04055\ h^{-1})(30.0\ h)}$

$$\boxed{R = 2.96\ kBq}$$

11:22

4 minutes

$1\ L = 1000\ cm^3$

17. - P117-2021-Final-Q17-Reg [4975924]
2.80 moles of ideal gas at a pressure of $1.60 \times 10^6$ Pa are in a container with a volume of 6.90 L. **A diagram is NOT required.**

(a) Calculate the temperature of the gas. 474 K

(b) Calculate the average kinetic energy of a gas molecule in the container. $9.82\times10^{-21}$ J

11:23

(a) $PV = nRT \Rightarrow T = \frac{PV}{nR} = \frac{(1.60\times10^6 Pa)\left(6.90L \times \frac{1000 cm^3}{L} \times \frac{1\ m^3}{(100 cm)^3}\right)}{(2.80 moles)(8.314\ J/K\cdot mole)}$

$T = 474 K$

(b) $KE = \frac{1}{2}mv_{rms}^2 = \frac{3}{2}k_B T = \frac{3}{2}(1.381\times10^{-23} J/K)(474 K) = 9.82\times10^{-21} J$

11:30

7 minutes