# Physics 152 Review

Arden Rasmussen

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# Contents

# 1 Chapter 14

## 1.1 Simple Harmonic Motion

$$F_x = ma_x = -kx \tag{1}$$

$$x\left(t\right) = Acos\left[\omega t + \delta\right] \tag{2}$$

$$\omega_{spring} = \sqrt{\frac{k}{m}} \tag{3}$$

$$\omega_{pendulum} = \sqrt{\frac{g}{l}} \tag{4}$$

$$E = K + U \tag{5}$$

$$= \frac{1}{2}kA^2 \tag{6}$$

$$\omega = 2\pi f \tag{7}$$

$$= \frac{2\pi}{T} \tag{8}$$

(1) The equation for the linear restoring force, where $k$ is the spring constant.

(2) The basic position equation, where $x$ is the positions, $A$ is the amplitude, $\omega$ is the angular frequency, $t$ is the time, and $\delta$ is the phase offset.

(3) The $\omega$ for a spring, where $k$ is the spring constant, and $m$ is the mass at the end of the spring.

(4) The $\omega$ for a simple pendulum, where $g$ is gravity, and $l$ is the length of the pendulum.

(5) The mechanical energy equaiton for a wave, where $E$ is total energy, $K$ is the kinetic energy, and $U$ is the potential energy.

(6) The mechanical energy equaiton for a wave, where $k$ is the spring constant, and $A$ is the amplitude.

(7) The angular frequency equation, where $\omega$ is the angular frequency, and $f$ is the frequency.

(8) The angular frequency equaiton, where $T$ is the period.

### 1.2 Damped Harmonic Motion

$$A = A_0 e^{\frac{t}{2\tau}} \tag{9}$$

$$E = E_0 e^{\frac{-t}{\tau}} \tag{10}$$

$$\tau = \frac{m}{b} \tag{11}$$

$$Q = \omega_0 \tau \tag{12}$$

$$\omega' = \omega_0 \sqrt{1 - \frac{1}{4Q^2}} \tag{13}$$

$$Q = \frac{1\pi}{\left(\frac{|\Delta E|}{E}\right)_{cycle}} \quad When \ \left(\frac{|\Delta E|}{E}\right)_{cycle} \ll 1 \tag{14}$$

(9) Amplitude equation, where $A_0$ is the initial amplitude, $t$ is the time, and $\tau$ is the decay time.

(10) Energy equation, where $E_0$ is the initial energy, $t$ is the time, and $\tau$ is the decay time.

(11) Decay time equation, where $\tau$ is the decay time, $m$ is the mass, and $b$ is the damping constant.

(12) Q factor definition, where $Q$ is the Q factor, $\omega_0$ is the initial angular frequency, and $\tau$ is the decay time.

(13) Frequency for a damped oscillation, where $\omega'$ is the angular frequency, $\omega_0$ is the initial angular frequency, and $Q$ is the Q factor.

(14) Q factor of weak dampining, where $Q$ is the Q factor, and $\left(\frac{|\Delta E|}{E}\right)_{cycle}$ is the percentage change of energy per cycle.

# 2 Chapter 15

## 2.1 Traveling Waves

$$v_{string} = \sqrt{\frac{F_T}{\mu}} \tag{15}$$

$$v_{sound} = \sqrt{\frac{B}{\rho}} \tag{16}$$

$$v_{sound} = 343\frac{m}{s} \tag{17}$$

$$c = 3.00x10^8\frac{m}{s} \tag{18}$$

$$r = \frac{v_2 - v_1}{v_2 + v_1} \tag{19}$$

$$\tau = \frac{2v_2}{v_2 + v_1} \tag{20}$$

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2} * \frac{\partial^2 y}{\partial^2} \tag{21}$$

(15) Speed of wave on a string, where $v$ is the velocity of the wave, $F_T$ is the tension force, and $\mu$ is the linear density of the string.

(16) Speed of sound wave in a fluid, where $v$ is the velocity of the wave, $B$ si the Bulk Modulus, and $\rho$ is the volume density of the fluid.

(17) Constant of the speed of sound in air.

(18) Constant of the spee dof light/electormagnetic waves in vacuum.

(19) Reflection coefficient equation, where $r$ is the reflection coefficient, $v_1$ is the wave velocity in the first region, and $v_2$ is the wave velocity in the second region.

(20) Transmission coefficient equatoin, where $\tau$ is the transmission coefficient, $v_1$ is the wave velocity in the first region, and $v_2$ is the wave velocity in the second region.

(21) Wave equation for a traveling wave.

## 2.2 Harmonic Traveling Waves

$$y(x,t) = Asin(kx \pm \omega t) \tag{22}$$
$$= Asin(k(x \pm vt)) \tag{23}$$
$$k = \frac{2\pi}{\lambda} \tag{24}$$
$$v = f\lambda \tag{25}$$
$$= \frac{\omega}{k} \tag{26}$$
$$\omega = s\pi f \tag{27}$$
$$= \frac{2\pi}{T} \tag{28}$$
$$P_{avg} = \frac{1}{2}\mu v \omega^2 A^2 \tag{29}$$
$$I = \frac{P_{avg}}{A} \tag{30}$$
$$\beta = (10dB)log_{10}\left(\frac{I}{I_0}\right) \tag{31}$$
$$I_0 = 10^{12}\frac{W}{m^2} \tag{32}$$

(22) Wave equation, where $y$ is the height, $x$ is the position, $t$ is the time, $A$ is the amplitude, $k$ is the wave number, and $\omega$ is the angular frequency. Use $+$ for waves traveling in the $+x$ direction, and use $-$ for waves traveling in the $-x$ direction.

(23) Wave equation, where $A$ is the amplitude, $k$ is the wave number, $x$ is the position, $v$ is the wave speed, and $t$ is the time.

(24) Wave number equation, where $k$ is the wave number, and $\lambda$ is the wave length.

(25) Wave speed equation, where $v$ is the wave speed, $f$ is the frequency, and $\lambda$ is the wavelenght.

(26) Wave speed equaiton, where $\omega$ is the angular frequency, and $k$ is the wave number.

(27) Angular frequency equation, where $\omega$ is the angular frequency, and $f$ is the frequency

(28) Angular frequency equation, where $T$ is the period.

(29) Average power for a harmonic wave on a string, where $P_{avg}$ is average power, $\mu$ is the linear density of the string, $v$ is the velocity of the string, $\omega$ is the angular frequency, and $A$ is the amplitude.

(30) Intensity of a harmonic wave, where $I$ is the intensity, $P_{acg}$ is the average power, and $A$ is the amplitude.

(31) Intensity of a wave in dB, where $\beta$ is the intensity in dB, $I$ is the intensity, and $I_0$ is a constant.

(32) Constant of $I_0$.

### 2.3 Doppler Shifts

$$f_r = \frac{v \pm u_r}{\lambda} \tag{33}$$

$$\lambda = \frac{v \pm u_s}{f_s} \tag{34}$$

$$f_r = \frac{v \pm u_r}{v \pm u_s} f_s \tag{35}$$

$$\frac{f_r}{v \pm u_r} = \frac{f_s}{v \pm u_s} \tag{36}$$

$$u \ll v \quad Where\ u = u_s \pm u_r \tag{37}$$

$$\frac{\Delta f}{f_s} \approx \pm \frac{u}{v} \tag{38}$$

(33) Frequency received when the receiver is moving, where $f_r$ is the frequency, $v$ is the speed of the wave, $u_r$ is the speed of the receiver, and $\lambda$ is the wavelength.

(34) Wavelength of wave when the source is moving, where $\lambda$ is the wavelength, $v$ is the speed of the wave, and $u_s$ is the speed of the source.

(35) Frequency if either the source or receiver is moving, where $f_r$ is the frequency received, $v$ is the speed of the wave, $u_r$ is the speed of the receiver, $u_s$ is the speed of the source, and $f_s$ is the frequency emited by the source. Choose signs that give and up-shift in frequency for an approaching source or receiver, and vice versa.

(36) Equation relating frequency of source and receiver, where $f_r$ is the frequency received, $v$ is the speed of the wave, $u_r$ is the speed of the recever, $f_s$ is the frequency emited by the source, and $u_s$ is the speed of the source.

(37) For small speed of the source and receiver comparitivly to the wave, the estimation is true, where $u$ is the speed of the source and receiver, $v$ is the speed of the wave, $u_s$ is the speed of the source, and $u_r$ is the speed of the receiver.

(38) This approximaition only holds if (37) is true, then this is true, where $\Delta f$ is the change in frequency, $f_s$ is the frequency emited by the source, $u$ is the velocity of the source and reciver from (37), and $v$ is the velocity of the wave.

# 3 Chapter 16

## 3.1 Superposition and Standing waves

$$y = y_1 + y_2 \tag{39}$$
$$= y_0 sin\,(kx - \omega t) + y_0 sin\,(kx - \omega t + \delta) \tag{40}$$
$$= \left(2y_0 cos\left(\frac{\delta}{2}\right)\right) sin\left(kx - \omega t + \frac{\delta}{2}\right) \tag{41}$$
$$\delta = k\Delta x \tag{42}$$
$$= 2\pi \frac{\Delta x}{\lambda} \tag{43}$$
$$\lambda_n = \frac{2L}{n} \quad n = 1, 2, 3, 4... \tag{44}$$
$$\lambda_n = \frac{4L}{n} \quad n = 1, 3, 5, 7... \tag{45}$$

The superposition of two waves with the same amplitude, wave number, andfrequency, but phase difference $\delta$, results in a harmonic wav eof the same wave number and frequency, but differing in phase and amplitude from each of the two waves.

(39) The amplitude of the wave is the sum of the amplitudes of each wave, where $y$ is the resultant value, $y_1$ is the value of the first wave, and $y_2$ is the value of the second wave.

(40) Superposition of two waves, where $y_0$ is the amplitude of the source, $k$ is the wave number, $x$ is the position, $\omega$ is the angular frequency, $t$ is the time, and $\delta$ is the phase difference.

(41) Superposition of two waves, where $y_0$ is the amplitude of the source, $\delta$ is the phase difference, $k$ is the wave number, $x$ is the position, $\omega$ is the angular frequency, and $t$ is the time.

(42) Phase difference due to path difference, where $\delta$ is the phase difference, $k$ is the wave number, and $\Delta x$ is the difference between distances from the two sources.

(43) Phase difference due to path difference, where $\Delta x$ is the difference between the distances from the two sources, and $\lambda$ is the wavelength.

(44) Wavelength for standing wave fixed at both ends, where $n$ is the wave number, $\lambda_n$ is the wavelength for that wave number, and $L$ is the length of string.

(45) Wavelength for standing wave fixed at one end, where $n$ is the wave number, $\lambda_n$ is the wavelength for that wave number, and $L$ is the length of string.

# 4 Chapter 31

## 4.1 Speed of Light

$$c = 299,792,458\frac{m}{s} \tag{46}$$

$$v = \frac{c}{n} \tag{47}$$

(46) Speed of light in a vacuum.

(47) Speed of light in a transparent medium, where $n$ is the index of refraction.

## 4.2 Reflection and Refraction

$$\theta_1 = \theta_1' \tag{48}$$

$$I = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2 I_0 \tag{49}$$

$$n = \frac{c}{v} \tag{50}$$

$$n_1 sin\theta_1 = n_2 sin\theta_2 \tag{51}$$

$$n_1 sin\theta_c = n_2 sin90 \tag{52}$$

$$\theta_c = sin^{-1}\left(\frac{n_2}{n_1}\right) \tag{53}$$

$$r = \frac{n_2 - n_1}{n_2 + n_1} \tag{54}$$

(48) Law of reflection.

(49) Reflected intensity.

(50) Index of refraction for a medium.

(51) Snell's Law(Law of refraction).

(52) Total internal reflection for critical angle.

(53) Critical angle for total internal reflection.

(54) Reflection coefficient.

## 4.3 Polarizaiton

$$I = I_0 cos^2\theta \tag{55}$$

$$\theta_p = tan^{-1}\left(\frac{n_2}{n_1}\right) \tag{56}$$

(55) Malus's Law, for intenisty of transimited light through angled polarizers.

(56) Angle of polarization from reflection.

# 5 Chapter 32

## 5.1 Mirrors

$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \tag{57}$$

$$f = \frac{r}{2} \tag{58}$$

$$m = \frac{y'}{y} = -\frac{s'}{s} \tag{59}$$

(57) Mirror equaiton, where $s$ is the position of the object, and $s'$ is the position of the image.

(58) Definition of focal length.

(59) Equation for lateral magnification.

## 5.2 Lenses

$$\frac{1}{f} = (n-1)\left(\frac{1}{f_1} - \frac{1}{f_2}\right) \tag{60}$$

(60) Lense-Maker's Equation. if $f > 0$ then the lense is converging, if $f < 0$ then the lense is diverging.

# 6 Chapter 33

## 6.1 Interference

$$\delta = k\Delta x = s\pi\frac{\Delta x}{\lambda} \tag{61}$$

$$\tag{62}$$

(61) Phase shift from path difference.

## 6.2 Diffraction

$$dsin(\theta_m) = m\lambda \;\; m = 0, 1, 2, \ldots \tag{63}$$

$$asin(\theta_m) = m\lambda \;\; m = 0, 1, 2, \ldots \tag{64}$$

$$dsin(\theta_m) = m\lambda \;\; m = 0, 1, 2, \ldots \tag{65}$$

$$\alpha_c = 1.22\frac{\lambda}{D} \tag{66}$$

(63) Diffraction grating maxima.

(64) Single slit interference minima.

(65) Two slit interference maxima.

(66) Rayleign's criterion.