PHY 1570

FINAL EXAM STUDY GUIDE

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GREEK ALPHABET

A	α	alpha
B	β	beta
Γ	γ	gamma
Δ	δ	delta
E	ϵ	epsilon
Z	ζ	zeta
H	η	eta
Θ	θ	theta
I	ι	iota
K	κ	kappa
Λ	λ	lambda
M	μ	mu
N	ν	nu
Ξ	ξ	xi
O	o	omicron
Π	π	pi
P	ρ	rho
Σ	σ	sigma
T	τ	tau
Υ	υ	upsilon
Φ	φ	phi
X	χ	chi
Ψ	ψ	psi
Ω	ω	omega

SI PREFIXES

exa-	E	10^{18}
peta-	P	10^{15}
tera-	T	10^{12}
giga-	G	10^{9}
mega-	M	10^{6}
kilo-	k	10^{3}
hecto-	h	10^{2}
deka-	da	10^{1}
deci-	d	10^{-1}
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	μ	10^{-6}
nano-	n	10^{-9}
pico-	p	10^{-12}
femto-	f	10^{-15}
atto-	a	10^{-18}

CONVENTIONAL SYMBOLS

		SI UNITS
x	DISTANCE	m
v	VELOCITY	m/s
a	ACCELERATION	m/s^2
ρ	DENSITY	kg/m^3
t	TIME	sec
p	MOMENTUM	kg m/s
W	WORK	J
K	KINETIC ENERGY	J
U	POTENTIAL ENERGY	J
E	TOTAL ENERGY	J
F	FORCE	N
m	MASS	kg
f	FREQUENCY	Hz
ω	ANGULAR FREQUENCY	rad/s
T	PERIOD	s
λ	WAVELENGTH	m
n	INDEX OF REFRACTION	—
g	ACCELERATION DUE TO GRAVITY	m/s^2
k	SPRING CONSTANT	N/m

STANDARD (NORMALIZED) SCIENTIFIC NOTATION.

$$\underbrace{4.56}_{\text{MANTISSA.}} \times 10^{3} \longleftarrow \text{EXPONENT}$$

SHOULD BE ≥ 1
AND < 10.

FORMULAE

$$x = \tfrac{1}{2}at^2 + v_0 t + x_0$$
$$v = at + v_0$$
$$v^2 = v_0^2 + 2a(x - x_0)$$

CONSTANT a

$$\rho = \frac{m}{V}$$

PROJECTILE:

$$R = \frac{v_0^2}{g}\sin 2\theta$$

$$h = \frac{v_0^2 \sin^2\theta}{2g}$$

$$p = mv$$

$$K = \tfrac{1}{2}mv^2$$

$$U = mgh$$

$$E = K + U$$

$$W = F \cdot x$$

$$f = \frac{1}{T}$$

$$\omega = 2\pi f$$

$$v_{snd} = (331 + 0.6\,T_c)$$

$$dB = 10\log_{10}\left(\frac{I}{I_0}\right)$$

$$I = I_0\,10^{dB/10}$$

$$I_0 = 10^{-12}\ W/m^2$$

SPHERE:

$$V = \frac{4}{3}\pi r^3$$

1 ft = 12 in

1 in = 2.54 cm

1 gal = 231 in^3

$g = 9.8\ m/s^2$

$= 32\ ft/s^2$

$v_{snd} = 343\ m/s$ @ 20°C

$c = 299792458\ m/s$

$$f' = f\left(\frac{v_{snd} \pm v_{obs}}{v_{snd} \mp v_{src}}\right)$$

TOP SIGN - TOWARD

BOTTOM SIGN - AWAY

PENDULUM: $T = 2\pi\sqrt{\frac{L}{g}}$

SPRING: $T = 2\pi\sqrt{\frac{m}{k}}$

$$\theta_i = \theta_r$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

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

SAMPLE PROBLEMS

① CONVERT TO STANDARD SCIENTIFIC NOTATION:

(a) 12,347

(b) 0.001472

(c) 832.4

(d) −12,781.22

(e) 0.00000472

② UNIT CONVERSIONS:

CONVERT 42 ft TO METERS BY DOING THESE STEPS:

(a) CONVERT 42 ft TO INCHES.

(b) CONVERT YOUR ANSWER TO PART (a) TO cm.

(c) " " " " " (b) TO METERS.

③ UNIT CONVERSION: CONVERT 500 cm^3 TO GALLONS. (1 GALLON = 231 in^3).

④ FIND THE DENSITY OF A SOLID SPHERE OF RADIUS 4.5 cm AND MASS 7600 g.

(5) GIVEN THE VECTORS

$\vec{A} = 5\hat{i} + 9\hat{j}$

$\vec{B} = 2\hat{i} - \hat{j}$

FIND: (a) $\vec{A} + \vec{B}$; (b) $\vec{A} - \vec{B}$; (c) $4\vec{B}$; AND (d) $|\vec{A}|$.

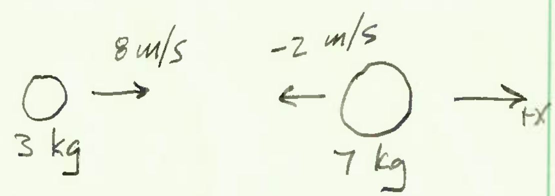
(6) FROM THE TOP OF A VERTICAL CLIFF, YOU RELEASE A ROCK FROM REST. IF THE ROCK TAKES 5.1 SECONDS TO FALL TO THE BOTTOM OF THE CLIFF, THEN:

(a) HOW HIGH IS THE CLIFF?

(b) WHAT IS THE ROCK'S IMPACT VELOCITY?

(7) PROJECTILE MOTION: IF A CANNON IS TILTED 27° FROM THE HORIZONTAL AND FIRES A CANNONBALL WITH A MUZZLE VELOCITY OF 52 m/s, THEN WHAT ARE THE: (a) RANGE; AND (b) MAXIMUM ALTITUDE OF THE CANNONBALL?

(8) PERFECTLY INELASTIC COLLISION. TWO BODIES ARE HEADED DIRECTLY TOWARD EACH OTHER AS SHOWN. WHEN THE BODIES COLLIDE, THEY STICK TOGETHER. WHAT IS THE POST-COLLISION VELOCITY OF THE AGGREGATE BODY?



(9) IN PROBLEM 8, (a) WHAT ARE THE KINETIC ENERGIES OF THE INDIVIDUAL 3 kg AND 7 kg BODIES BEFORE THE COLLISION?

(b) WHAT IS THE KINETIC ENERGY OF THE AGGREGATE BODY AFTER THE COLLISION?

(10) WHAT IS THE WORK DONE IN APPLYING A FORCE OF 18 N TO A BODY OVER A DISTANCE OF 12 m? (THE FORCE IS IN THE DIRECTION OF MOTION.)

(11) (a) IF SIMPLE HARMONIC OSCILLATOR HAS A FREQUENCY OF 120 Hz, THEN WHAT IS THE PERIOD OF MOTION? (b) WHAT IS ITS ANGULAR FREQUENCY?

(12) WHAT IS THE SPEED OF SOUND IN AIR AT: (a) 20°C; (b) 60°C?

(13) (a) IF A SOUND HAS AN INTENSITY OF 1.75×10^{-6} W/m², THEN WHAT IS THE SOUND LEVEL IN dB?

(b) IF A SOUND HAS A SOUND LEVEL OF 87 dB, THEN WHAT IS ITS INTENSITY IN W/m²?

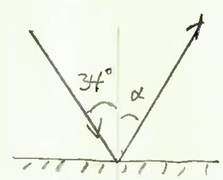
(14) IF A FIRE ENGINE IS MOVING DIRECTLY TOWARD YOU AT $50 \frac{m}{s}$, EMITTING A SOUND FROM ITS SIREN WITH A FREQUENCY OF 400 Hz (AT REST), THEN WHAT IS THE FREQUENCY OF THE SOUND YOU HEAR?

(15) (a) A PENDULUM HAS A LENGTH OF 3.8 m. WHAT IS ITS PERIOD OF OSCILLATION?

(b) A MASS OF 2 kg IS HANGING FROM A VERTICAL SPRING, AND OSCILLATES WITH A PERIOD OF 0.210 SECONDS, THEN WHAT IS THE SPRING CONSTANT k OF THE SPRING?

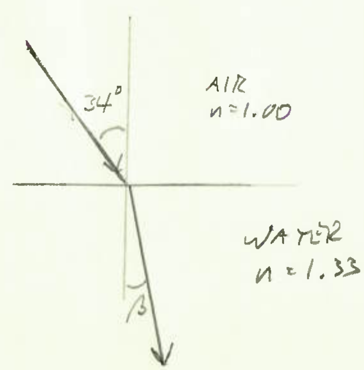
(16) (a) IN THIS FIGURE SHOWING LIGHT REFLECTION, WHAT IS THE ANGLE OF REFLECTION α?

(a)



(b) IN THIS FIGURE SHOWING LIGHT REFRACTION, WHAT IS THE ANGLE OF REFRACTION β?

(b)



SOLUTIONS

① (a) 1.2347×10^4

(b) 1.472×10^{-3}

(c) 8.324×10^2

(d) -1.278122×10^4

(e) 4.72×10^{-6}

② (a) $42 \text{ ft} \times \frac{12 \text{ in}}{1 \text{ ft}} = \underline{504 \text{ in}}$

(b) $504 \text{ in} \times \frac{2.54 \text{ cm}}{1 \text{ in}} = \underline{1280.16 \text{ cm}}$

(c) $1280.16 \text{ cm} \times \frac{1 \text{ m}}{100 \text{ cm}} = \boxed{12.8016 \text{ m}}$

③ $500 \text{ cm}^3 \times \left(\frac{1 \text{ in}}{2.54 \text{ cm}}\right)^3 \times \frac{1 \text{ gal}}{231 \text{ in}^3}$

$= \boxed{0.1321 \text{ gal}}$

④ $\rho = \frac{m}{V}$; $V = \frac{4}{3}\pi r^3$

$r = 4.5$ cm, SO VOLUME $V = \frac{4}{3}\pi(4.5 \text{ cm})^3 = 381.7035 \text{ cm}^3$

THEN DENSITY $\rho = \frac{m}{V} = \frac{7600 \text{ g}}{381.7035 \text{ cm}^3} = \boxed{19.91 \text{ g/cm}^3}$

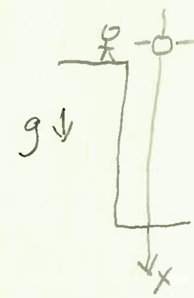
5 (a) $\vec{A} + \vec{B} = 7\hat{i} + 8\hat{j}$

(b) $\vec{A} - \vec{B} = 3\hat{i} + 10\hat{j}$

(c) $4\vec{B} = 8\hat{i} - 4\hat{j}$

(d) $|\vec{A}| = \sqrt{5^2 + 9^2} = \sqrt{106} = \underline{10.2956}$

6 (a) CHOOSE THE x AXIS TO BE POINTING DOWNWARD, WITH ITS ORIGIN AT THE RELEASE POINT. THEN x AT ANY TIME t IS



$$x(t) = \frac{1}{2}at^2 + v_0 t + x_0$$

HERE: $a = +g$

$v_0 = 0$ (RELEASED FROM REST)

$x_0 = 0$ (CHOICE OF ORIGIN)

SO

$$x(t) = \frac{1}{2}gt^2$$

$$= \frac{1}{2}(9.8\ m/s^2)(5.1\ s)^2$$

$$= \boxed{127.449\ m}$$

(b) THERE ARE SEVERAL WAYS TO DO THIS, FOR EXAMPLE: METHOD 1: USE

$$v^2 = v_0^2 + 2a(x - x_0)$$

$a = +g$

$v_0 = 0$

$x_0 = 0$

SO

$$v^2 = 2gx$$

$$v = \sqrt{2gx}$$

6b (CONT'D)

USING $x = 127.449$ m FROM PART (a),

$$v = \sqrt{2gx} = \sqrt{2(9.8\ m/s^2)(127.449\ m)}$$

$$= \underline{49.98\ m/s}$$

METHOD 2: USE INSTEAD

$$v(t) = at + v_0$$

WITH

$$a = +g$$
$$v_0 = 0$$

WE HAVE

$$v = gt$$
$$= (9.8\ m/s^2)(5.1\ s)$$
$$= \underline{49.98\ s}$$

METHOD 3: CONSERVATION OF ENERGY. AT THE TOP OF THE CLIFF, THE ROCK'S TOTAL ENERGY IS

$$E_0 = K_0 + U_0$$
$$= \frac{1}{2}m\underbrace{v_0}_{0}{}^2 + mgh = mgh$$

AT THE BOTTOM OF THE CLIFF,

$$E_f = K_f + \underbrace{U_f}_{=0}$$
$$= \frac{1}{2}mv^2$$

BY CONSERVATION OF ENERGY,

$E_0 = E_f$, SO $\cancel{m}gh = \frac{1}{2}\cancel{m}v^2$

$$v = \sqrt{2gh} = \underline{49.98\ s.}$$

WE GET THE SAME ANSWER ALL THREE WAYS.

7

(a) $R = \dfrac{v_0^2}{g} \sin 2\theta$

$= \dfrac{(52\ m/s)^2}{9.8\ m/s} \sin(2 \times 27°)$

$= \dfrac{(52\ m/s)^2}{9.8\ m/s^2} \sin 54°$

$= \boxed{223.223\ m}$

(b) $h = \dfrac{v_0^2 \sin^2\theta}{2g}$

$= (\sin 27°)^2$

$= \dfrac{(52\ m/s)^2 (\sin^2 27°)}{2\,(9.8\ m/s^2)}$

$= \boxed{28.434\ m}$

(8) BY CONSERVATION OF MOMENTUM, THE TOTAL MOMENTUM OF THE SYSTEM BEFORE THE COLLISION EQUALS THE TOTAL MOMENTUM AFTER THE COLLISION.

BEFORE THE COLLISION:

$$
\begin{aligned}
p_i &= m_1 v_1 + m_2 v_2 \\
&= (3\ \text{kg})(8\ \text{m/s}) + (7\ \text{kg})(-2\ \text{m/s}) \\
&= 24\ \text{kg m/s} - 14\ \text{kg m/s} \\
&= 10\ \text{kg m/s}.
\end{aligned}
$$

AFTER THE COLLISION, THE BODIES STICK TOGETHER, AND WE HAVE A SINGLE AGGREGATE BODY OF MASS $3\ \text{kg} + 7\ \text{kg} = 10\ \text{kg}$. ITS MOMENTUM MUST ALSO BE $10\ \text{kg m/s}$, BY CONSERVATION OF MOMENTUM:

$$
\begin{aligned}
p_f = (m_1 + m_2) v &= p_i = 10\ \text{kg m/s} \\
(3\ \text{kg} + 7\ \text{kg}) v &= 10\ \text{kg m/s} \\
(10\ \text{kg}) v &= 10\ \text{kg m/s} \\
v &= \frac{10\ \text{kg m/s}}{10\ \text{kg}} = \boxed{1\ \text{m/s}}
\end{aligned}
$$

(9) (a) $K_1 = \frac{1}{2} m_1 v_1^2 = \frac{1}{2}(3\ \text{kg})(8\ \text{m/s})^2 = \underline{96\ \text{J}}$

$K_2 = \frac{1}{2} m_2 v_2^2 = \frac{1}{2}(7\ \text{kg})(-2\ \text{m/s})^2 = \underline{14\ \text{J}}$

(b) $K_f = \frac{1}{2}(m_1 + m_2) v^2 = \frac{1}{2}(10\ \text{kg})(1\ \text{m/s})^2 = \underline{5\ \text{J}}$

(10) $W = F \cdot x$

$= (18\ N)(12\ m)$

$= \boxed{216\ J}$

(11) (a) $f = 120\ Hz$, so PERIOD

$T = \frac{1}{f} = \frac{1}{120\ Hz} = 0.0083\ sec = \boxed{8.333\ ms}$

(b) $\omega = 2\pi f = 2\pi(120\ Hz) = \boxed{753.982\ rad/s}$

(12) $v_{snd} = (331 + 0.6\ T_c)\ m/s$

(a) AT 20°C, $v_{snd} = (331 + 12)\ m/s$

$= \underline{343\ m/s}$

(b) AT 60°C, $v_{snd} = (331 + 36)\ m/s$

$= \underline{367\ m/s}$

13 (a) $dB = 10 \log_{10}\left(\frac{I}{I_0}\right)$; $I_0 = 10^{-12} \frac{W}{m^2}$

$$dB = 10 \log_{10} \frac{1.75 \times 10^{-6} \ W/m^2}{10^{-12} \ W/m^2}$$

$$= 10 \log_{10} (1.75 \times 10^{6})$$

$$= 10 \ (6.2430)$$

$$= \boxed{62.43 \ dB}$$

(b) $I = I_0 \, 10^{dB/10}$

$$= \left(10^{-12} \frac{W}{m^2}\right)\left(10^{87 \, dB/10}\right)$$

$$= \left(10^{-12} \frac{W}{m^2}\right)\left(10^{8.7}\right)$$

$$= 10^{-3.3} \ W/m^2$$

$$= \boxed{5.0119 \times 10^{-4} \ W/m^2}$$

14 DOPPLER EFFECT:

$$f' = f\left(\frac{V_{snd} \pm V_{obs}}{V_{snd} \mp V_{src}}\right)$$

TOP SIGN - TOWARD
BOTTOM SIGN - AWAY

$$= f\left(\frac{V_{snd} + V_{obs}}{V_{snd} - V_{src}}\right)$$ (TOWARD)

$V_{obs} = 0$, $V_{snd} = 343 \ m/s$, $V_{src} = 50 \ m/s$
$f = 400 \ Hz$

so

$$f' = (400 \ Hz)\left(\frac{343 + 0}{343 - 50}\right)$$

$$= \boxed{468.26 \ Hz}$$

15 (a)

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$= 2\pi\sqrt{\frac{3.8\,m}{9.8\,m/s^2}}$$

$$= \boxed{3.9125\ sec}$$

(b) $T = 2\pi\sqrt{\frac{m}{k}}$

SOLVE FOR k:

$$\frac{T}{2\pi} = \sqrt{\frac{m}{k}}$$

$$\frac{T^2}{4\pi^2} = \frac{m}{k}$$

$$\frac{4\pi^2}{T^2} = \frac{k}{m}$$

$$k = \frac{4\pi^2 m}{T^2} = \frac{4\pi^2 (2\ kg)}{(0.210\ s)^2}$$

$$\boxed{k = 1790.40\ N/m}$$

16 (a) $\alpha = 34°$

(b) SNELL'S LAW:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$n_1 = 1.00$, $\theta_1 = 34°$

$n_2 = 1.33$ $\theta_2 = ?$

$$\sin\theta_2 = \frac{n_1}{n_2}\sin\theta_1$$

$$= \frac{1.00}{1.33}\sin 34°$$

$$= 0.4204$$

$$\theta_2 = \sin^{-1}(0.4204)$$

$$\boxed{\theta_2 = 24.86°}$$