**SPH3U Exam Review**
**Answer Section**

## PROBLEM

1.

(a) distance travelled

$\Delta d = v\Delta t$

$= 80\ \text{km/h}(1.5\ \text{h})$

$= 120\ \text{km}$

$\Delta d = v\Delta t$

$= 50\ \text{km/h}(2.0\ \text{h})$

$= 100\ \text{km}$

total distance travelled: 120 km + 100 km = 220 km

average speed

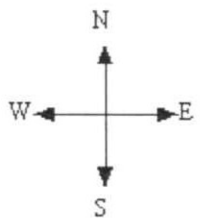
$v = \dfrac{\Delta d}{\Delta t}$

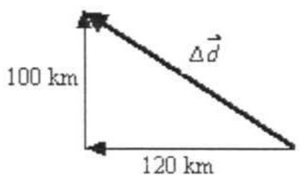
$= \dfrac{220\ \text{km}}{3.5\ \text{h}}$

$= 63\ \text{km/h}$

**The car's average speed is 63 km/h.**

(b) displacement




$\Delta\vec{d} = 156\ \text{km}\ [50^\circ\ \text{W of N}]$

(Pythagoras)

average velocity

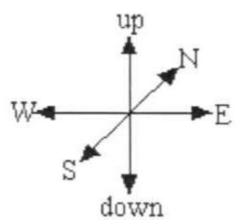
$\vec{v} = \dfrac{\Delta\vec{d}}{\Delta t}$

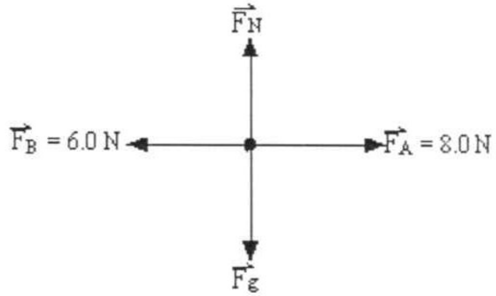
$= \dfrac{156\ \text{km}\ [50^\circ\ \text{W of N}]}{3.6\ \text{h}}$

$= 45\ \text{km/h}\ [50^\circ\ \text{W of N}]$

**The car's average velocity is 45 km/h [50° W of N].**

2. (a)




(b)

$\vec{F}_{net} = \vec{F}_A + \vec{F}_B + \vec{F}_f$

$\vec{F}_{net} = m\vec{a}$

$= 1.5\ \text{kg}\left(1.0\ \text{m/s}^2\ [\text{E}]\right)$

$= 1.5\ \text{N}\ [\text{E}]$

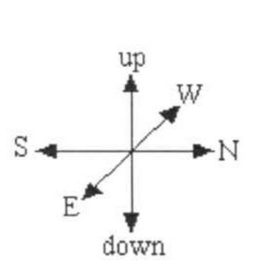
$\vec{F}_f = \vec{F}_{net} - \vec{F}_A - \vec{F}_B$

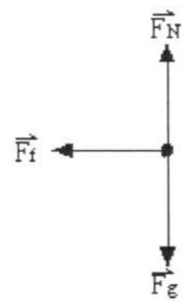
$= 15\ \text{N}\ [\text{E}] - 8.0\ \text{N}\ [\text{E}] - 6.0\ \text{N}\ [\text{W}]$

$= 0.5\ \text{N}\ [\text{W}]$

**The frictional force is 0.5 N [W].**

3. (a)




(b) $\vec{F}_{net} = \vec{F}_f$

$= 0.42 \text{ N [S]}$

$\vec{a} = \dfrac{\vec{F}_{net}}{m}$

$= \dfrac{0.42 \text{ N [S]}}{0.350 \text{ kg}}$

$= 1.2 \text{ m/s}^2 \text{ [S]}$

**The puck's acceleration is 1.2 m/s² [S].**

(c) $\Delta d = \dfrac{v_f^2 - v_i^2}{2a}$

$= \dfrac{(0.0 \text{ m/s})^2 - (6.0 \text{ m/s})^2}{2(-1.2 \text{ m/s}^2)}$

$= 15 \text{ m}$

**The puck slides for 15 m.**

4.

(a) Let [up] be "negative" and let [down] be "positive."


$$\Delta d = v_i \Delta t + \frac{a \Delta t^2}{2}$$

$$-4.0 \text{ m} = v_i (0.90 \text{ s}) + \frac{9.8 \text{ m/s}^2 (0.90 \text{ s})^2}{2}$$

$$v_i = -8.9 \text{ m/s}$$

**The speed upon release is 8.9 m/s.**

(b) $a = \dfrac{v_f^2 - v_i^2}{2\Delta d}$

$= \dfrac{(-8.85 \text{ m/s})^2 - (0.0 \text{ m/s})^2}{2(-1.2 \text{ m})}$

$= -33 \text{ m/s}^2$

**The acceleration during the throw is 33 m/s² [up].**

(c) $\vec{F}_A$ = applied force

$\vec{F}_g$ = gravity

$\vec{F}_A = \vec{F}_{net} - \vec{F}_g$

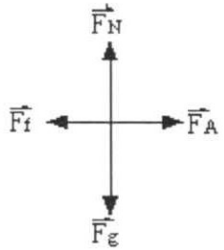
$= m\vec{a} - m\vec{g}$

$= 2.0 \text{ kg}\left(-32.7 \text{ m/s}^2\right) - 2.0 \text{ kg}\left(9.8 \text{ N/kg}\right)$

$= -85 \text{ N}$

**The force exerted must be 85 N [up].**

5. Let [fwd] be "positive" and [bkwd] be "negative".




$$\vec{F}_f = \vec{F}_{net} - \vec{F}_A$$
$$= m\vec{a} - \vec{F}_A$$
$$= 3.4\text{ kg}\left(1.6\text{ m/s}^2\right) - (7.2\text{ N})$$
$$= -1.8\text{ N}$$

**The frictional force acting is 1.8 N [bkwd].**

6. $$\vec{F}_{net} = m\vec{a}$$
$$= 1.5\text{ kg}\left(0.50\text{ m/s}^2\right)$$
$$= 0.75\text{ N}$$

$$\vec{F}_f = \vec{F}_{net} - \vec{F}_A$$
$$= 0.75\text{ N} - 1.2\text{ N}$$
$$= -0.45\text{ N}$$

$$\mu = \frac{F_f}{F_N}$$
$$= \frac{F_f}{F_g}$$
$$= \frac{F_f}{mg}$$
$$= \frac{0.45\text{ N}}{1.5\text{ kg}\left(9.8\text{ N/kg}\right)}$$
$$= 0.031$$

**The frictional force acting is 0.45 N [bkwd] and the coefficient of kinetic friction is 0.031.**

7. $$F_A = 8.4\text{ N [N]} + 3.6\text{ N [S]}$$
$$= 4.4\text{ N [N]}$$

$$F_f = \mu F_N$$
$$= \mu F_g$$
$$= \mu mg$$
$$= 0.15\left(2.4\text{ kg}\right)\left(9.8\text{ N/kg}\right)$$
$$= 3.53\text{ N (this is acting opposite the motion, south)}$$

$$\vec{F}_{net} = \vec{F}_A + \vec{F}_f$$
$$= 4.4\text{ N [N]} + 3.53\text{ N [S]}$$
$$= 0.87\text{ N [N]}$$

$$\vec{a} = \frac{\vec{F}_{net}}{m}$$

$$= \frac{0.87\ \text{N [N]}}{2.4\ \text{kg}}$$

$$= 4 \times 10^{-1}\ \text{m/s}^2\ \text{[N]}$$

**The object will accelerate at a rate of $4 \times 10^{-1}$ m/s$^2$ [N].**

8. $F_f = \mu_s F_N$

$$= \mu_s F_g$$

$$= \mu_s mg$$

$$= 0.20(1.0\ \text{kg})(9.8\ \text{N/kg})$$

$$= 2.0\ \text{N}$$

**An applied force of 2.0 N [fwd] would be required to get this object sliding.**

9.

(a) Scales read the force of gravity.

$$m = \frac{F_g}{g}$$

$$= \frac{500\ \text{N}}{9.8\ \text{N/kg}}$$

$$= 51\ \text{kg}$$

on new planet: $F_g = mg$

$$= 51.0\ \text{kg}(14\ \text{N/kg})$$

$$= 7.1 \times 10^2\ \text{N}$$

**The scales would read $7.1 \times 10^2$ N.**

(b) $d = \left(\frac{Gm_1 m_2}{F_g}\right)^{\frac{1}{2}}$

$$= \left(\frac{6.67 \times 10^{-11}\ \text{Nm}^2/\text{kg}^2 (51.0\ \text{kg})(7.0 \times 10^{24}\ \text{kg})}{714\ \text{N}}\right)^{\frac{1}{2}}$$

$$= 5.8 \times 10^6\ \text{m}$$

**The planet's radius is $5.8 \times 10^6$ m.**

(c) $F_2 = \frac{F_1 d_1{}^2}{d_2{}^2}$

$$= \frac{714\ \text{N}(5.77 \times 10^6\ \text{m})^2}{(8.57 \times 10^6\ \text{m})^2}$$

$$= 3.2 \times 10^2\ \text{N}$$

**This person would weigh $3.2 \times 10^2$ N.**

10. $m = 15.0$ kg

$|\vec{g}| = 9.80$ N/kg

$\Delta\vec{d} = 10.0$ m

$W = ?$

$$F = \left|\vec{F}_g\right|$$

$$= m\left|\vec{g}\right|$$

$$= (15\ \text{kg})(9.80\ \text{N/kg})$$

$$= 147\ \text{N}$$

$$W = F\Delta d$$

$$= (147\ \text{N})(10.0\ \text{m})$$

$$= 1470\ \text{J}$$

**The work done by Marisa on the soap box car over the 10.0 m if friction is ignored is 1470 J.**

11. $m_1 = 2.5$ kg
$m_2 = 1.0$ kg
$\Delta h_1 = -1.0$ m
$\Delta h_2 = +1.0$ m

$$\Delta E_{g1} = m_1 g \Delta h_1$$

$$= (2.5\ \text{kg})(9.8\ \text{N/kg})(-1.0\ \text{m})$$

$$= -24.5\ \text{J}$$

$$\Delta E_{g2} = m_2 g \Delta h_2$$

$$= (1.0\ \text{kg})(9.8\ \text{N/kg})(+1.0\ \text{m})$$

$$= +9.8\ \text{J}$$

$$\Delta E_T = \Delta E_{g1} + \Delta E_{g2}$$

$$= -24.5\ \text{J} + 9.8\ \text{J}$$

$$= -14.7\ \text{J}$$

$$\Delta E_K = -\Delta E_T = 14.7\ \text{J}$$

$$\Delta E_K = E_{K2} - E_{K1}$$

$$E_{K2} = E_{K1} + \Delta E_K$$

$$\frac{1}{2}(m_1 + m_2)v_2{}^2 = 0\ \text{J} + \Delta E_K$$

$$v_2{}^2 = \frac{2(14.7\ \text{J})}{2.5\ \text{kg} + 1.0\ \text{kg}}$$

$$= 8.4\ \text{m}^2/\text{s}^2$$

$$v_2 = 2.9\ \text{m/s}$$

**The speed of each mass when the 2.5-kg mass has fallen 1.0 m from the rest position is 2.9 m/s.**

12. $m = 140$ kg
$t_{\text{initial}} = 45.0°\text{C}$
$t_{\text{final}} = 15.0°\text{C}$
$c = 4.18 \times 10^3$ J/kg·°C
$Q_{\text{lost}} = ?$

$$Q_{\text{lost}} = mc\Delta t$$

$$= (0.140\ \text{kg})(4.18 \times 10^3\ \text{J/kg}\cdot°\text{C})(45°\text{C} - 15°\text{C})$$

$$= 1.76 \times 10^4\ \text{J}$$

**The heat lost is 1.76 × 10⁴ J.**

13. $P = 45.0\ \text{kW} = 4.5 \times 10^4$ W
mass of elevator ($m_1$)= $2.00 \times 10^3$ kg
$h = 35.0$ m
$t = 20.0$ s
number of passengers = 6
mass of elevator and passengers ($M$) = ?
mass of each passenger ($m_2$) = ?

$\Delta E_p = Mg\Delta h$

$$P = \frac{\Delta E_p}{\Delta t}$$

$$= \frac{Mg\Delta h}{\Delta t}$$

$$4.5 \times 10^4 \text{ W} = \frac{M(9.80 \text{ N/kg})(35.0 \text{ m})}{20.0 \text{ s}}$$

$$M = 2.62 \times 10^3 \text{ kg}$$

$$6m_2 = M - m_1$$

$$= 2.62 \times 10^3 \text{ kg} - 2.00 \times 10^3 \text{ kg}$$

$$6m_2 = 6.20 \times 10^2 \text{ kg}$$

$$m_2 = 1.03 \times 10^2 \text{ kg}$$

**The mass of each passenger on the elevator was $1.03 \times 10^2$ kg.**

14. $P = 1000$ W
$m_w = 500 \text{ g} = 0.500 \text{ kg}$
$\Delta t = 55°\text{C} - 10°\text{C} = 45°\text{C}$
$t = 2.0 \text{ min} = 120 \text{ s}$
$c_w = 4.18 \times 10^3 \text{ J/kg}\cdot°\text{C}$

$$Q(E_{out}) = mc\Delta t$$

$$= (0.500 \text{ kg})(4.18 \times 10^3 \text{ J/kg}\cdot°\text{C})(45°\text{C})$$

$$= 9.4 \times 10^4 \text{ J}$$

$$P = \frac{\Delta E}{\Delta t}$$

$$1000 \text{ W} = \frac{\Delta E}{120 \text{ s}}$$

$$\Delta E = 1.2 \times 10^5 \text{ J}$$

$$\text{efficiency} = \frac{E_{out}}{E_{in}}$$

$$= \frac{9.4 \times 10^4 \text{ J}}{1.2 \times 10^5 \text{ J}}$$

$$= 78\%$$

**The efficiency of the energy transformation is 78%.**

15. $\lambda = 1.5$ m
$N = 25$ cycles
$t = 5.0$ s
$v = ?$

$$f = \frac{N}{t}$$

$$= \frac{25 \text{ cycles}}{5.0 \text{ s}}$$

$$= 5.0 \text{ Hz}$$

$$v = f\lambda$$

$$= (5.0 \text{ Hz}) \times (1.5 \text{ m})$$

$$= 7.5 \text{ m/s}$$

**The speed of the waves is 7.5 m/s.**

16. 5 loops

$v = 17.5$ m/s

$f = 1.40 \times 10^2$ Hz

length = ?

$v = f\lambda$

$\lambda = \frac{v}{f}$

$= \frac{17.5 \text{ m/s}}{140 \text{ Hz}}$

$= 0.125$ m

1 loop $= \frac{1}{2}\lambda$

$= 0.0625$ m

5 loops $= 0.3125$ m

**The string is 0.313 m long.**

17. $N = 20$ vibrations

$t = 0.50$ s

$v_{sound} = 350$ m/s

$\lambda = ?$

The frequency must first be calculated using:

$f = \frac{N}{t}$

$= \frac{20 \text{ vibrations}}{0.50 \text{ s}}$

$= 40$ Hz

Now the wavelength can be calculated using:

$v = f\lambda$

$\lambda = \frac{v}{f}$

$= \frac{350 \text{ m/s}}{40 \text{ Hz}}$

$= 8.75$ m

**The wavelength of the sound is 8.8 m.**

18. $v_{sound} = 345$ m/s

$t_{near} = 0.75$ s (echo) $= 0.375$ s (one way)

$t_{far} = 1.50$ s (echo) $= 0.750$ s (one way)

$d_{width} = d_{near} + d_{far} = ?$

$d = vt$

$d_{near} = (v_{sound})(t_{near})$

$= (345 \text{ m/s})(0.375 \text{ s})$

$= 129.375$ m

$d_{far} = (v_{sound})(t_{far})$

$= (345 \text{ m/s})(0.750 \text{ s})$

$= 258.75 \text{ m}$

$d_{width} = d_{near} + d_{far}$

$= 129.375 \text{ m} + 258.75 \text{ m}$

$= 388.125 \text{ m}$

**The width of the valley is $3.8 \times 10^2$ m.**

19. number of beats = 24

total time = 6.0 s

$f_1 = 512 \text{ Hz}$

$f_{string} = ?$

$$f_{beat} = \frac{\text{number of beats}}{\text{total time}}$$

$$= \frac{24}{6.0 \text{ s}}$$

$= 4.0 \text{ Hz}$

$f_{beat} = |f_1 - f_2|$

$\pm f_{beat} = f_1 - f_2$

$f_2 = f_1 \pm f_{beat}$

$f_{string} = 512 \text{ Hz} \pm 4.0 \text{ Hz}$

$f_{string} = 516 \text{ Hz or } 508 \text{ Hz}$

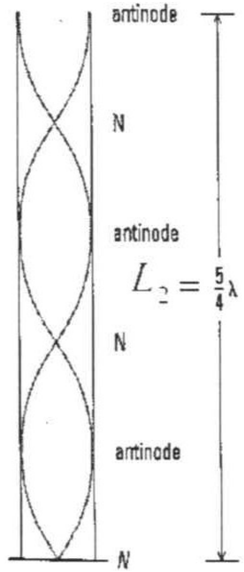
**The possible frequencies of the guitar string are 508 Hz and 516 Hz.**

20. mode = second overtone

$L_2 = 25.0 \text{ cm}$

$v_{sound} = 352 \text{ m/s}$

$f_2 = ?$




$L_2 = \frac{5}{4}\lambda$

$25.0 \text{ cm} = \frac{5}{4}\lambda$

$\lambda = 20 \text{ cm}$

$= 0.200 \text{ m}$

$v = f\lambda$

$f = \frac{v}{\lambda}$

$f = \frac{352 \text{ m/s}}{0.200 \text{ m}}$

$= 1760 \text{ Hz}$

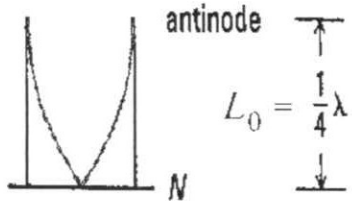
**The frequency the singer is producing is 1.76 × 10$^3$ Hz.**

21. mode = fundamental mode

$f_0 = 75.0 \text{ Hz}$

$v_{sound} = 343 \text{ m/s}$

$L_0 = ?$




$v = f\lambda$

$\lambda = \frac{v}{f}$

$= \frac{343 \text{ m/s}}{75.0 \text{ Hz}}$

$= 4.5733 \text{ m}$

$L_0 = \frac{1}{4}\lambda$

$= \frac{1}{4}(4.5733 \text{ m})$

$= 1.1433 \text{ m}$

**The length of the pipe must be 1.14 m.**

22. $m = 250$ g
$\Delta T = 97°C - 15°C = 82°C$
$c_w = 4.184$ J/g·°C
$V = 12.0$ V
$\Delta t = 5.0 \text{ min} = 3.00 \times 10^2$ s
$I = ?$

$V = \frac{E}{Q}$

$Q = \frac{E}{V}$

$E = Q_w$ (Note: $Q_w$ refers to the heat

$Q_w = mC\Delta T$

$= (250 \text{ g})(4.184 \text{ J/g} \cdot °C)(82° C)$

$= 8.6 \times 10^4 \text{ J}$

transferred to the water.)

$$I = \frac{Q_w}{\Delta t}$$
$$= \frac{E}{V\Delta t}$$
$$= \frac{8.6 \times 10^4 \text{ J}}{(12.0 \text{ V})(3.00 \times 10^2 \text{ s})}$$
$$= 23.9 \text{ A}$$

**The current is 24 A.**

23. $V_T = 120$ V
$R_1 = 10.0\ \Omega$
$I_T = 15.0$ A
$R_2 = ?$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$\frac{1}{R_2} = \frac{1}{R_T} - \frac{1}{R_1}$$
$$= \frac{1}{10.0\ \Omega} - \frac{1}{15.0\ \Omega}$$
$$= \frac{1}{30.0\ \Omega}$$
$$R_2 = 30.0\ \Omega$$

$$R_T = \frac{V_T}{I_T}$$
$$= \frac{120 \text{ V}}{12.0 \text{ A}}$$
$$= 10.0\ \Omega$$

**An additional 30.0 Ω of resistance is needed.**

24. $P = 1500$ W
$I = 10.0$ A
$R = ?$

$$P = I^2 R$$
$$R = \frac{P}{I^2}$$
$$= \frac{1500 \text{ W}}{(10.0 \text{ A})^2}$$
$$= 15\ \Omega$$

**The resistance is 15 Ω.**

25.

(a) $R_n = 120\ \Omega$
$V_T = 120$ V

$$\frac{1}{R_T} = 6\left(\frac{1}{R_n}\right)$$
$$= 6\left(\frac{1}{120\ \Omega}\right)$$
$$= \frac{1}{20\ \Omega}$$
$$R_T = 20\ \Omega$$

**The total resistance is 20 Ω.**

(b) $R = 20\ \Omega$
$V = 120$ V
$I = ?$

$$R = \frac{V}{I}$$

$$I = \frac{V}{R}$$

$$= \frac{120\ \text{V}}{20\ \Omega}$$

$$= 6.0\ \text{A}$$

**The current is 6.0 A.**

26.

(a) $R_n = 25\ \Omega$
$V = 120\ \text{V}$
$R_T = ?$

$$R_T = 10(R_n)$$

$$= 10(25\ \Omega)$$

$$= 250\ \Omega$$

**The total resistance is $2.5 \times 10^2\ \Omega$.**

(b) $R = 250\ \Omega$
$V = 120\ \text{V}$
$I = ?$

$$R = \frac{V}{I}$$

$$I = \frac{V}{R}$$

$$= \frac{120\ \text{V}}{250\ \Omega}$$

$$= 0.48\ \text{A}$$

**The current is 0.48 A.**

27. $R_s = 15.0\ \Omega$
$V_s = 30.0\ \text{V}$
$V_p = 120\ \text{V}$
$N_p = 200$
$\Delta t = 1\ \text{min} = 60.0\ \text{s}$
$I_s = ?$
$I_p = ?$
$P = ?$
$\Delta E = ?$

(a) $R = VI$

$$I_s = \frac{V_s}{R_s}$$

$$= \frac{30.0\ \text{V}}{15.0\ \Omega}$$

$$= 2.00\ \text{A}$$

**The current in the secondary coil is 2.00 A.**

(b) $\frac{N_p}{N_s} = \frac{V_p}{V_s}$

$\frac{N_p}{N_s} = \frac{I_s}{I_p}$

$\frac{V_p}{V_s} = \frac{I_s}{I_p}$

$I_p = \frac{V_s I_s}{V_p}$

$= \frac{(30.0\ \text{V})(2.00\ \text{A})}{120\ \text{V}}$

$= 0.50\ \text{A}$

**The current in the secondary coil is 0.50 A**

(c) $P = VI$

$P_s = V_s I_s$

$= (30.0\ \text{V})(2.00\ \text{A})$

$= 60.0\ \text{W}$

$P_s = P_p$

$P_p = 60.0\ \text{W}$

**The power rating is 60.0 W.**

(d) $\Delta E = P\Delta t$

$= (60.0\ \text{W})(60.0\ \text{s})$

$= 3.60 \times 10^3\ \text{J}$

**It used $3.60 \times 10^3$ J of energy.**

28. $I_s = 75.0$ A
$V_s = 60.0$ V
$V_p = 240$ V
$P = ?$

$P = VI$

$= (60.0\ \text{V})(75.0\ \text{A})$

$= 4.5 \times 10^3\ \text{W}$

**The power rating is $4.5 \times 10^3$ W.**