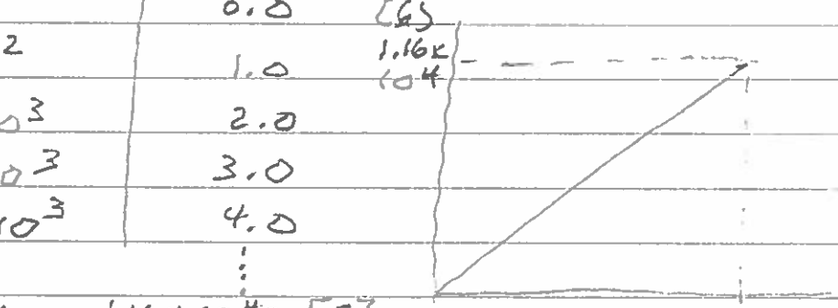
SPH3U Exam Review Solutions

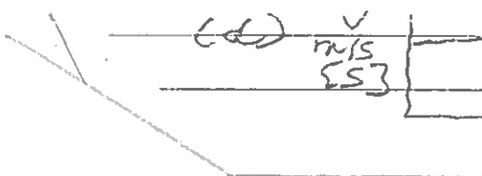
1. 110 km/h x 1000 m/km x 1 hr/3600 s
   = 30.6 m/s
2. 38.0 m/s x 1 km/1000 m x 3600 s/1 h
   = 136.8 = 137 km/h
3. 1500 dm to m = 150 m
4. 0.150 km to cm = 15000 cm
5. Scalar – distance, speed
   Vector – displacement, velocity
6. - average speed is total distance ÷ total time.
   - instantaneous speed is speed at a particular instant (as on a speedometer)
7. $d = 3.9\text{km} + 180.2\text{km} + 42.2\text{km} = 226.3\text{km} = 2.263 \times 10^5\text{ m}$
   $t = 8\text{h } 17\text{ min } 17\text{s}$
   $= 8\text{h}(3600\text{s/h}) + 17\text{min}(60\text{s/min}) + 17\text{s} = 29837\text{s}$
   $v_{av} = \frac{d}{t} = \frac{2.263 \times 10^5\text{ m}}{29837\text{s}} = 7.584\text{ m/s} = 27.30\text{ km/h}$
8. - uniform motion – motion at a constant speed in a straight line
   ex. car traveling down straight at 100 km/h
   - non-uniform motion – motion in which object's speed and/or direction changes.
   ex. on at ride at Wonderland traveling in a circle at a constant speed of 1.2 m/s
9. $\vec{v}_{av} = \frac{\Delta \vec{d}}{\Delta t}$ (change in position ÷ total time)
10. 

11. (a)

position (m [S])	time (s)
0.0	0.0
9.3×10^2	1.0
1.86×10^3	2.0
2.79×10^3	3.0
3.72×10^3	4.0
⋮	⋮

(b) 

(c) $\text{slope} = \frac{\Delta d}{\Delta t} = \frac{1.16 \times 10^4\text{ m [S]}}{12.0\text{s}} = 9.3 \times 10^2\text{ m/s [S]}$

(d) 

(e) $\text{area} = lw$
$= 9.3 \times 10^2 (12)$
$= 1.1 \times 10^4\text{ m [S]}$

12. $\Delta\vec{d}$ = area

$= \frac{1}{2}(5)(8) + 5(8) = 60\ m$

slope $= \frac{8}{5} = 1.6\ m/s^2$, slope $= 0$, slope $= -\frac{8}{5} = -1.6\ m/s^2$

13. $\vec{V}_{bw} = 15\ m/s\ [N]$ $\quad V_{bg} = V_{bw} + V_{wg}$

$\vec{V}_{wg} = 10\ m/s\ [E]$ $\quad = 15\ m/s\ [N] + 10\ m/s\ [E]$

$V_{bg} = ?$ $\quad = 18\ m/s\ [N34°E]$

$\theta = \tan^{-1}\left(\frac{10}{15}\right) = 34°$

14. $\vec{d}_1 = 5.0\ km\ [E]$

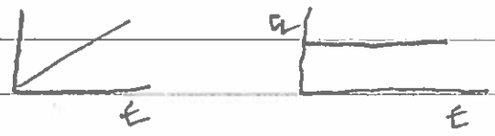
$\vec{d}_2 = 4.0\ km\ [S]$

$\vec{d}_3 = 10.0\ km\ [S30°W]$

$\Delta\vec{d} = ?$

	x comp	y comp
$\vec{d}_1$ →	+5	0
$\vec{d}_2$ ↓	0	−4
$\vec{d}_3$ 10 at 30°	$10\sin 30 =$ −5	$10\cos 30 =$ −8.66
$\Sigma\vec{d}$	0	−12.66

$\therefore\ \Delta\vec{d} = 13\ km\ [S]$

15. 

16. $V_1 = 0$, $V_2 = 21.0\ m/s\ [W]$, $\Delta t = 9.0\ s$

$a_{av} = \frac{V_2 - V_1}{\Delta t} = \frac{21 - 0}{9} = 2.3\ m/s^2\ [W]$

17. $V_1 = 1.0 \times 10^3\ m/s\uparrow$, $V_2 = 1.0 \times 10^4\ m/s\uparrow$, $a_{av} = 31\ m/s^2$

$\Delta t = ?$ $\quad \Delta t = \frac{V_f - V_i}{a_{av}} = \frac{1.0 \times 10^4 - 1.0 \times 10^3}{31} = 290\ s$

18. $V_1 = 4.0\ m/s\uparrow$, $\Delta t = 2.2\ s$, $V_2 = ?$ $\quad a = g = 9.8\ m/s^2$

$V_1 = 4.0\ m/s\downarrow$, $\Delta t = 2.2\ s$, $V_2 = ?$

(a) $V_2 = V_1 + a\Delta t = 4.0 + (-9.8)(2.2) = 18\ m/s\downarrow$

(b) $V_2 = V_1 + a\Delta t = -4.0 + (-9.8)(2.2) = 26\ m/s\downarrow$

19. $\Delta d = \left(\frac{V_1 + V_2}{2}\right)\Delta t$ $\quad V_2^2 = V_1^2 + 2a\Delta d$

$V_2 = V_1 + a\Delta t$ $\quad \Delta d = V_2\Delta t - \frac{1}{2}a\Delta t^2$

$\Delta d = V_1\Delta t + \frac{1}{2}a\Delta t^2$

20. $V_1 = 52\ m/s\ [W]$, $a_{av} = 2.8\ m/s^2\ [W]$, $\Delta t = 5.0\ s$

$V_2 = ?$, $\Delta d = ?$

a) $V_2 = V_1 + a\Delta t = 52 + 2.8(5) = 66\ m/s\ [W]$

b) $\Delta d = V_1\Delta t + \frac{1}{2}a\Delta t^2 = 52(5) + \frac{1}{2}(2.8)(5)^2 = 295\ m\ [W]$

21. $V_1 = 0$, $a = 1.8\ m/s^2\ [fwd]$, $\Delta t = ?$, $\Delta\vec{d} = 95\ m\ [fwd]$ $= 3.0 \times 10^2\ m\ [fwd]$

$\Delta d = V_1\Delta t + \frac{1}{2}a\Delta t^2$ ($V_1 = 0$)

$\Delta t = \sqrt{\frac{2\Delta d}{a}} = \sqrt{\frac{2(95)}{1.8}} = 1.0 \times 10^1\ s$

22. 4 fundamental forces:
gravitational 1, electromagnetic 10^{20}
strong nuclear 10^{38}, weak nuclear 10^{25}

23. Newton's 1st Law – an object will remain at rest or continue to move at constant velocity when the net force on it is zero.
ex. seatbelted person in car – brakes applied
Newton's 2nd law – an object will accelerate in the direction of the net force as F_{net} acts on m
ex. volleyball serve
Newton's 3rd Law – each action force has a reaction force that is equal in magnitude and opposite in direction.
ex. pushing against the boards on skates

24. a) $F_{net} = 27\ N\ [W]$, $m = 63\ kg$, $a = ?$
$a = \frac{F_{net}}{m} = \frac{27}{63} = 0.43\ m/s^2\ [W]$
b) $F_{net} = 18\ N\ [fwd]$, $m = 7.5\ kg$, $a = ?$
$a = \frac{F_{net}}{m} = \frac{18}{7.5} = 2.4\ m/s^2\ [fwd]$
c) $F_{net} = 32\ N\ [up]$, $m = 95\ g = 0.095\ kg$
$a = \frac{F_{net}}{m} = \frac{32}{0.095} = 3.4 \times 10^2\ m/s^2\ [up]$

25. a) $m = 5.0\ kg$, $a = 5.0 \times 10^3\ m/s^2$, $F_{net} = ?$
$F_{net} = ma = 5\ (5.0 \times 10^3) = 2.5 \times 10^4\ N\ [fwd]$
b) $m = 28\ g = 0.028\ kg$, $a = 2.5 \times 10^3\ m/s^2\ [E]$, $F_{net} = ?$
$F_{net} = ma = 0.028\ (2.5 \times 10^3) = 7.0 \times 10^1\ N\ [E]$
c) $m = 1.6 \times 10^5\ kg$, $a = 1.2\ m/s^2\ [S]$ $F_{net} = ?$
$F_{net} = ma = 1.6 \times 10^5\ (1.2) = 1.9 \times 10^5\ N\ [S]$

26. gravitational field strength – the force per kg of mass acting on an object within a gravitational field.
$\frac{N}{kg} = \frac{kg \cdot m/s^2}{kg} = \frac{m}{s^2}$

27. mass – quantity of matter in object, kg
weight – measure of the force of gravity on an object, N (F_g)
– mass never changes due to location or changes in gravitational field strength and is measured using a balance

28. Static friction - the force exerted on a stationary object by a surface that prevents the object from starting to move.
Starting friction - maximum static friction and the amount of force that must be overcome to start a stationary object moving.
Kinetic friction - the force exerted on a moving object by a surface in a direction opposite to the direction of motion

29. coefficient of friction - μ, ratio of the magnitude of the force of friction, F_f, to the magnitude of the normal force, F_N.
$\mu = \frac{F_f}{F_N}$

30. $m = 252\ kg$, $V_{constant}$, $F_{net} = 425\ N = F_f$
a) $\mu_k = \frac{F_f}{F_N} = \frac{425}{mg} = \frac{425}{252(9.8)} = 0.17$
b) nothing happens - does not change
c) $m = 252 + 56 = 308\ kg$, $g = 9.8\ m/s^2$
$F_f = \mu F_N = 0.17(308)9.8 = 5.1 \times 10^2 N$

31. Energy is the capacity to do work $W = \Delta E$

32. Energy transformation is the change of one type of energy into another.
ex pendulum swing $E_g \rightarrow E_K \rightarrow E_g$ etc

33. Law of conservation of energy - energy is neither created nor destroyed just transformed into another form.

34. Work - is done on an object when a force displaces an object in the direction of the force or a component of the force, J

35. $F = 95N$, $\Delta d = 16m$, $W = ?$
$W = F \cdot \Delta d = 95(16) = 1.5 \times 10^3 J = 1.5\ kJ$

36. a) $m = 8.1\ kg$, $g = 9.8\ N/kg$, $F_g = ?$
$F_g = mg = 8.1(9.8) = 79N$
b) $\Delta d = 92\ cm = 0.92\ m$, $W = ?$
$W = F_g \cdot \Delta d = 79(0.92) = 73J$

37. $F = 250N$, $\Delta d = 0$, $W = ?$
$W = F \cdot \Delta d = 250(0) = 0$

38. $F = 32N$, $\Delta d = 7.8m$, $W = ?$
$W = F \cdot \Delta d = 32(7.8) = 2.5 \times 10^2 J$

39. $m = 60$ (assume) kg, $g = 9.8$ N/kg, $\Delta d = 36$ m, $W = ?$
$W = F_g \cdot \Delta d = mg\Delta d = 60(9.8)(36) = 2.1 \times 10^4$ J

40. - gravitational potential energy, E_g - the energy possessed by an object because of its position relative to a lower positio
- kinetic energy, E_K - the energy due to the motion of an object
- mechanical energy, $E_T = E_g + E_K$

41. $m = 485\,g = 0.485$ kg, $\Delta h = 62$ cm $= 0.62$ m
a) $\Delta h = 0$ $\therefore E_g = 0$
b) $E_g = mg\Delta h = 0.485(9.8)(0.62) = 2.9$ J

42. a) $m = 7.2$ kg, $v = 12$ m/s, $E_K = ?$
$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(7.2)(12)^2 = 5.2 \times 10^2$ J
b) $m = 140$ kg, $v = 14$ m/s, $E_K = ?$
$E_K = \frac{1}{2}mv^2 = \frac{1}{2}(140)(14)^2 = 1.4 \times 10^4$ J

43. power - the rate of doing work or transforming energy, W

44. $W = J/s = Nm/s = kg \cdot m/s^2 \cdot m/s = kg \cdot m^2/s^3$

45. $m = 85$ kg, $\Delta h = 3690$ m $- 2900$ m $= 740$ m, $\Delta t = 3600$ s
$E_g = mg\Delta h = 85(9.8)(740) = 616420$ J
$P = \frac{\Delta E}{\Delta t} = \frac{616420\,J}{3600\,s} = 1.7 \times 10^2$ W

46. Periodic motion - when an object repeats a pattern of motion. ie. a bouncing spring

47. frequency - # cycles per second, Hz - f
period - time required for 1 cycle, s - T
$f = \frac{1}{T}$, $T = \frac{1}{f}$

48. a) # cycles $= 1800$, $T = 1$ min $= 60$ s
$f = \frac{1800}{60} = 30$ Hz $\quad T = \frac{1}{f} = \frac{1}{30} = 3.3 \times 10^{-2}$ s
b) # cycles $= 1800$, $T = 20.0$ s
$f = \frac{1800}{20.0} = 90$ Hz, $T = \frac{1}{f} = \frac{1}{90} = 1.1 \times 10^{-2}$ s
c) # cycles $= 460 + 640$, $T = 1$ min $= 60$ s
$f = \frac{460}{60} = 7.7$ Hz, $T = \frac{1}{f} = \frac{1}{7.7} = 1.3 \times 10^{-2}$ s
$f = \frac{640}{60} = 10.7$ Hz $= 11$ Hz, $T = \frac{1}{f} = \frac{1}{10.7} = 9.4 \times 10^{-2}$ s
d) $f = \frac{60\text{ cycles}}{60\,s} = 1$ Hz, $T = \frac{1}{f} = \frac{1}{1} = 1$ s
e) $f = \frac{60\text{ cycles}}{3600\,s} = 1.6 \times 10^{-2}$ Hz, $T = \frac{1}{f} = \frac{1}{0.16} = 60$ s.

49. transverse wave - the particles in a medium vibrate at right angles to the direction in which the wave travels.

50. A - crest, B - λ, C - amplitude, D - trough

51. Longitudinal wave - the particles vibrate parallel to the direction of motion of the wave.

52. $V = f\lambda$

53. $\lambda = 0.080\ m$, $f = 2.5\ Hz$, $V = ?$
$V = f\lambda = 2.5(0.080) = 0.20\ m/s$

54. $\lambda = 4.0\ m$, $\Delta d = 9.0\ m$, $\Delta t = 4.5\ s$, $f = ?$
$V = \frac{\Delta d}{\Delta t} = \frac{9.0\ m}{4.5\ s} = 2.0\ m/s$
$f = \frac{V}{\lambda} = \frac{2.0}{4.0} = 0.50\ Hz$

55. $T = 1.18 \times 10^{-3}\ s$, $V = 3.4 \times 10^{2}\ m/s$, $\lambda = ?$
$\lambda = \frac{V}{f} = V \cdot T = 3.4 \times 10^{2}(1.18 \times 10^{-3}) = 0.40\ m$

56. $\Delta t = 5.25$, $\Delta d = 19\ m$, # cycles = 20, $T = 1.75$
$V = \frac{\Delta d}{\Delta t} = \frac{19\ m}{5.25} = 3.65\ m/s$
$f = \frac{20\ cycles}{1.75} = 1.18\ Hz$
$\lambda = \frac{V}{f} = \frac{3.65}{1.18} = 3.1\ m$

57. constructive interference - occurs when pulses build each other up resulting in a larger amplitude
destructive interference - occurs when a crest meets a trough

58. principle of superposition - at any point the resulting amplitude of two interfering waves is the algebraic sum of the displacements of the individual waves.

59. resonance - the response of an object that is free to vibrate to a periodic force with the same frequency as the natural frequency of the object.

60. -Standing wave - if conditions are controlled so that waves have the same amplitude and wavelength, yet travel in opposite directions, a standing wave occurs.
- node - a point that remains at rest during the interference
- antinode - midway between nodes where double crests and double troughs occur.

61. $f = 28\,Hz$, $\lambda = 9.5\,cm = 0.095\,m$
$d_n = \frac{1}{2}\lambda = \frac{1}{2}(9.5\,cm) = 4.75\,cm$

62. Sound – a form of energy produced by rapidly vibrating objects that can be heard by the human ear.

63. infrasonic – $f < 20\,Hz$
ultrasonic – $f > 20000\,Hz$

64. $f = 8.8 \times 10^2\,Hz$, $\lambda = 4.1 \times 10^{-1}\,m$, $V = ?$
$V = f\lambda = 8.8 \times 10^2 (4.1 \times 10^{-1}) = 3.6 \times 10^2\,m/s$

65. a) $T = 21°C$ $V = 331.4 + 0.606(21) = 344.1\,m/s$
b) $T = 24°C$ $V = 331.4 + 0.606(24) = 345.9\,m/s$
c) $T = -35°C$ $V = 331.4 + 0.606(-35) = 310.2\,m/s$

66. $V = 331.4 + 0.606T$, $T = ?$
$T = \frac{V - 331.4}{0.606}$

67. echo – the sound that reflects off a surface back to a device or person that produced the sound.

68. $\Delta d = 86\,m \times 2 = 172\,m$, $\Delta t = 0.50\,s$, $V = ?$
$V = \frac{\Delta d}{\Delta t} = \frac{172\,m}{0.50\,s} = 344\,m/s$

69. $\Delta d = 420\,m \times 2 = 840\,m$, $\Delta t = 0.50\,s$, $V = ?$
$V = \frac{\Delta d}{\Delta t} = \frac{840\,m}{0.60\,s} = 1400\,m/s$

70. beats – periodic changes in sound intensity

71. $f_1 = 512\,Hz$, $f_2 = 514\,Hz$, $b.f. = ?$
$b.f. = |f_1 - f_2| = |512 - 514| = 2\,Hz$

72. doppler effect – the apparent changeing frequency of sound in relation to an object's motion

73. $T = 0°C$, $V_s = 332\,m/s$, $V_{source} = 100.0\,km/h = 27.8\,m/s$, $f = 440\,Hz$
$f_{obs} = ?$
a) $f_{obs} = \left(\frac{V_s + V_d}{V_s + V_{source}}\right) f_{obs} = \left(\frac{332}{332 - 27.8}\right) 440 = 4.8 \times 10^2\,Hz$
b) $f_{obs} = \left(\frac{332}{332 + 27.8}\right) 440 = 4.0 \times 10^2\,Hz$

74. Mach # – the ratio of the airspeed of an object to the local speed of sound
$M = \frac{\text{airspeed of obj}}{\text{local speed of sound}}$

75. a) $T = 0°C$, airspeed $= 1440\,km/h = 400\,m/s$, Mach #
$M\# = \frac{400\,m/s}{331.4\,m/s} = 1.2$
$V = 331.4 + 0.606(0) = 331.4$
b) airspeed $= 920\,km/h = 255.5\,m/s$
$M\# = \frac{255.5}{331.4} = 0.77$

76. fundamental frequency – the string vibrates in one segment, lowest frequency

77. closed air column
- resonance occurs at $\frac{1}{4}\lambda, \frac{3}{4}\lambda$ .....

78. open air column
- resonances occurs at $\frac{1}{2}\lambda, \lambda$ .....

79. a) $\frac{1}{4}\lambda = 9.0\,cm$ $\therefore \lambda = 36\,cm$
b) $\frac{3}{4}\lambda = \frac{3}{4}(36) = 27\,cm$

80. a) $\frac{1}{4}\lambda = 16\,cm$ $\therefore \lambda = 64\,cm = 0.64\,m$
b) $V = f\lambda = 512(0.64) = 328\,m/s = 3.3 \times 10^2\,m/s$

81. a) fundamental $= \frac{1}{2}\lambda$
$\frac{1}{2}\lambda = 3.6\,m$ $\therefore \lambda = 7.2\,m$
b) $V = f\lambda$
$f = \frac{V}{\lambda} = \frac{346\,m/s}{7.2\,m} = 48\,Hz$

82. - free-end reflection – a reflection that occurs at a media boundary where the second medium is less dense than the first medium; reflections have the same orientation as the original wave.
- fixed-end reflection – a reflection that occurs at a media boundary where one end of the medium is unable to vibrate; reflections are inverted.
- media boundaries: amplitudes
when a wave encounters a media boundary that is not strictly an ideal free-end or fixed-end boundary, the wave splits into two; one wave is reflected and one is transmitted.
(see diagrams on pg. 422 of text)
- standing waves – see # 60 above