Student 7
Average 22.3/50
Best 45.0/50

# 12th Physics (2018 – 19)

(2nd Q, #2 Mini Test)

| Class | No. | Name Solutions |
|---|---|---|

**In calculation problems, describe equations clearly and systematically enough to show how to solve the problems.**

| | |
|---|---|
| The circular constant | $\pi = 3.14159...$ |
| Gravitational acceleration rate | $g = 9.80\ m/s^2$ |
| The mechanical equivalence of heat | $1\ cal = 4.186\ J$ |
| Volume of a sphere | $V = \frac{4}{3}\pi r^3$ |
| Avogadro's Number | $N_A = 6.022 \times 10^{23}\ mol^{-1}$ |
| Universal Gas Constant | $R = 8.314\ J/(mol \cdot K)$ |
| Boltzmann Constant | $k = 1.381 \times 10^{-23}\ J/K$ |

| Specific Heat c [J/(kg · K)] | |
|---|---|
| Water | 4186 |
| Ice | 2090 |
| Steam | 2010 |
| Oil | 1970 |
| Copper | 387 |
| Ceramic | 1090 |
| Glass | 837 |
| Aluminum | 900 |
| Iron (Steel) | 560 |
| Lead | 128 |

| | Coefficient of Thermal Expansion [K⁻¹] |
|---|---|
| Lead | $29 \times 10^{-6}$ |
| Aluminum | $24 \times 10^{-6}$ |
| Brass | $19 \times 10^{-6}$ |
| Copper | $17 \times 10^{-6}$ |
| Iron (Steel) | $12 \times 10^{-6}$ |
| Concrete | $12 \times 10^{-6}$ |
| Window glass | $11 \times 10^{-6}$ |
| Pyrex glass | $3.3 \times 10^{-6}$ |
| Quartz | $0.50 \times 10^{-6}$ |

4 pt/question x 13 questions = 52 pt Max 50 pt

/[Total 50 pt]



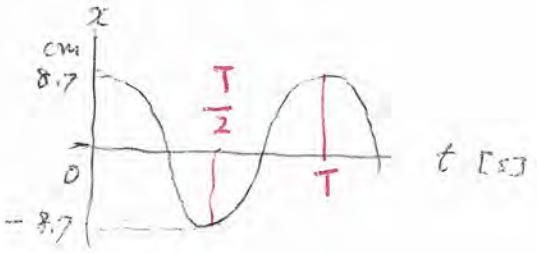
1/11/2018 By Tohei Moritani

(1) The position of a mass oscillating on a spring is given by: $x = (8.7\ cm)\cos[2\pi t/(0.86\ s)]$.
(1-a) What is the frequency of this motion?
(1-b) When is the mass first at the position $x = -8.7\ cm$?
Equations

(a) $f$? $f = \frac{1}{T} = \frac{1}{0.86} = 1.16 \rightarrow 1.2\ [Hz]$

(b) $t = \frac{T}{2} = \frac{0.86}{2} = 0.43$

$0.43\ [s]$




| (1-a) Answer | 1.2 Hz |
|---|---|
| (1-b) Answer | 0.43 s |

(61%)

(2) The springs of a 511-kg motorcycle have an effective force constant of 9130 N/m.
(2-a) If a person sits on the motorcycle, does its period of oscillation increase, decrease, or stay the same?
(2-b) By what percent does the period of oscillation change when 112-kg person rides the motorcycle?
Equations

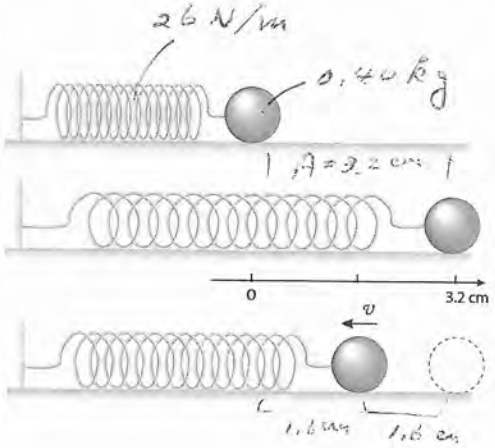
(a) $k = 9130\ N/m$ , $T = 2\pi\sqrt{\frac{m}{k}}$ m increases → T increases

(b)
$$\frac{T'}{T} = \sqrt{\frac{m'}{m}} = \sqrt{\frac{511+112}{511}} = 1.1042 \longrightarrow 10.4\%$$

| (2) Answer |
| --- |
| (a) increases |
| (b) 10.4% |

(82%)

(3) A 0.40-kg mass is attached to spring with a force constant of 26 N/m and released from rest a distance of 3.2 cm from the equilibrium position of the spring. Find the speed of the mass when it is halfway to the equilibrium position.




$x = 1.6$ cm  $v$ ?

~~$x = A\cos\frac{2\pi}{T}t$~~

Conservation of mechanical energy

$$\frac{1}{2}kx^2 + \frac{1}{2}mv^2 = \frac{1}{2}kA^2$$

$$x = \frac{A}{2}$$

$$mv^2 = kA^2 - k\frac{A^2}{4} = \frac{3}{4}kA^2$$

$$v = A\sqrt{\frac{3k}{4m}}$$

$$= 3.2\sqrt{\frac{3\times 26}{4\times 0.40}}$$

$$= 22.34$$

$$\longrightarrow 22 \text{ cm/s}$$

| (3) Answer | | |
|---|---|---|
| | 22 cm/s | (20%) |

(4) A person rides on a mechanical bucking bull that oscillates up and down with simple harmonic motion. The period of the bucking is 0.74 s and the amplitude is slowly increasing. At a certain amplitude the rider must hang on to prevent separating from the mechanical bull. Find the amplitude.

$T = 0.74\ s$

$x = A\cos\frac{2\pi}{T}t$

$a_{max} = A\omega^2 = A\left(\frac{2\pi}{T}\right)^2 \geq 9.80$

$A \geq 9.80 \times \frac{T^2}{4\pi^2} = 9.80 \times \frac{0.74^2}{4\pi^2}$

$= 0.136\ m \rightarrow 14\ cm$

(4) Answer

14 cm (32%)

(5) A 3.2-kg balloon is filled with helium (density = 0.179 kg/m$^3$). If the baloon is sphere with a radius of 5.2 m, what is the maximum weight it can lift?
Equations

air (density = 1.29 kg/m$^3$)


$$\rho_{air} V g \geqq m g + m_{He} g + W$$
$$= m g + \rho_{He} V g + W$$

$$W \leqq V g (\rho_{air} - \rho_{He}) - m g$$

$$V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \times 5.2^3 = \overline{589}\ [m^3]$$

$$W \leqq \overline{589} \times 9.80 \times (1.29 - 0.179) - 3.2 \times 9.80$$
$$= \overline{6413} - \overline{31}$$
$$= \overline{6382} \longrightarrow 6400\ N$$

(5) Answer: 6400 N (3P/6)

(6) (6-a) Find the pressure difference on an airplane wing if air flows over the upper surface with a speed of 117 m/s, and along the bottom surface with a speed of 105 m/s.
(6-b) If the area of the wing is 32 $m^2$, what is the net upward force exerted on the wing?

(a)

$$P_u + \frac{1}{2}\rho v_u^2 = P_d + \frac{1}{2}\rho v_d^2$$

$v_u$ 117 m/s $P_u$

$v_d$ 105 m/s $P_d$

$$\Delta P = P_d - P_u = \frac{1}{2}\rho (v_u^2 - v_d^2)$$

$$= \frac{1}{2} \times 1.29 \times (117^2 - 105^2) = 1718\ [Pa] \longrightarrow 1700\ [Pa]$$

$= \frac{1}{2} \times 1.29 \times (\overline{13689} - \overline{11025})$

$= \frac{1}{2} \times 1.29 \times \overline{2664}$

2 digits

$= \frac{1}{2} \times 1.29 \times 13689 - \frac{1}{2} \times 1.29 \times 11025$

$= \overline{8829} - \overline{7111}$

$= \overline{1718}$ 3 digits

(b) $P = \frac{F}{A} \rightarrow F = PA$

$= 1718 \times 32$

$= 54,985\ N$

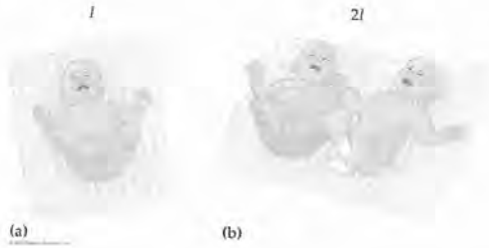
$\longrightarrow 55\ kN$

or 1720 Pa

| | |
|---|---|
| (6-a) Answer | 1700 Pa |
| (6-b) Answer | 55 kN |

(36%)

(7) A crying child emits sound with an intensity of 9.0 x $10^{-6}$ W/m$^2$.
(7-a) Find the intensity level <u>in decibels</u> for the child's sounds.
(7-b) Find the intensity level <u>in decibels</u> for this child and its twin, both crying with identical intensities.
Equations




(a) $\beta = 10 \log (I / I_0)$

$= 10 \log (9 \times 10^{-6} / 10^{-12})$

$= 10 \log (9 \times 10^{6}) = 10 (\log 9 + 6)$

$= 10 (0.954 + 6) = 10 \times 6.954$

$= 69.54 \longrightarrow 70\,dB$

(b) $\beta = 10 \log (2 \times 9 \times 10^{6})$

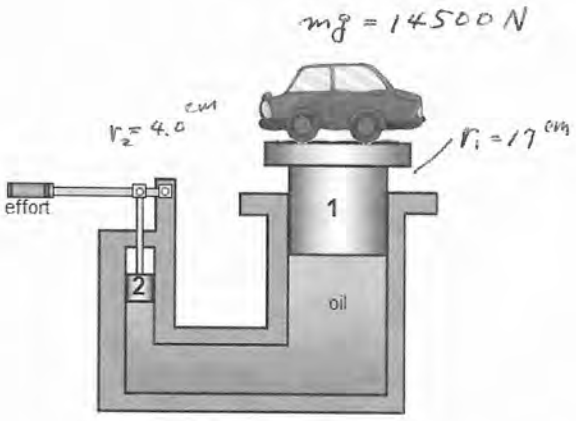
$= 3.010 + 9.54 + 60$

$= 72.55 \longrightarrow 73\,dB$

| | |
|---|---|
| (7-a) Answer | 70 dB |
| (7-b) Answer | 73 dB |

(2 pts)

(8) To inspect a 14,500-N car, it is raised with a hydraulic lift. If the radius of the small piston 2 in the figure is 4.0 cm, and the radius of the large piston 1 is 17 cm, find the force that must be exerted on the small piston to lift the car.
Equations




$P_1 = P_2$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$\frac{F_1}{\pi r_1^2} = \frac{F_2}{\pi r_2^2}$$

$$F_2 = \left(\frac{r_2}{r_1}\right)^2 \times F_1$$

$$= \left(\frac{4.0}{17}\right)^2 \times 14500$$

$$= 0.0554 \times 14500$$

$$= 803 \longrightarrow 800\ [N]$$

(8) Answer

800 N

(45%)

(9) The world's longest suspension bridge is the Akashi Kaikyo Bridge in Japan. The bridge is 3910 m long and is constructed of steel. How much longer is the bridge on a warm summer day (30.0℃) than on a cold winter day (− 5.00℃)?

Thermal expansion

$\Delta L = \alpha L_i \Delta T$

$= 12 \times 10^{-6} \times 3910 \times 35.0$

$= 1.642 \longrightarrow 1.64m$

| (9) Answer | 1.64m |
|---|---|

(46%)

(10) The temperature of 40 kg water in a bathtub is 45℃. You want to make 42℃ bath by adding 10℃ water to the bathtub. How much should you add? Equations

$Q_h + Q_c = 0$

$Q = m c \Delta T$

$40 \times 4186 (-45) + m \times 4186 \times (42-10) = 0$

$40 \times (-3) + 32 m = 0$

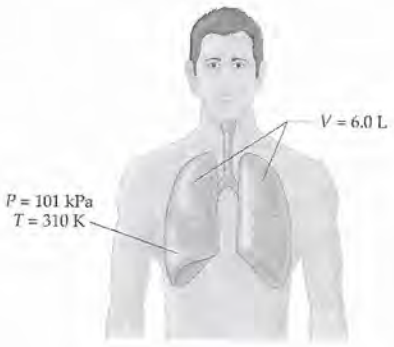
$m = \frac{120}{32} = 3.75 \longrightarrow 4 \ [kg]$

(10) Answer

4 kg

(88%)

(11) A person's lungs might hold 6.0 L (1L = 10−3 m3) of air at body temperature (310 K) and atmospheric pressure (101 kPa). Given that the air is 21% oxygen, find the number of oxygen molecules in the lungs.




Equations

$N$ ?

$$PV = NkT$$

$$N = \frac{PV}{kT}$$

$$= \frac{101\times10^{3} \times 6.0 \times10^{-3}}{1.381\times10^{-23} \times 310}$$

$$= 1.415 \times 10^{23}$$

$$1.416 \times 10^{23} \times 0.21 = 0.298 \times 10^{23}$$

$$\longrightarrow \quad 3.0 \times 10^{22}$$

(11) Answer

$3.0 \times 10^{22}$ molecules (43%)

(12) Find the root-mean square (rms) speed of N2 (28.0 g/mol) at 300 K.
Equations

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

$$= \sqrt{\frac{3 \times 8.31 \times 300}{28.0 \times 10^{-3}}}$$

$$= 516.8 \longrightarrow 517 \ [m/s]$$

(12) Answer

517 m/s (16%)

(13) A balloon at 300 K holds 0.98 mol of helium molecules. Find the internal energy of the helium in the balioon.
Equations

$T = 300 K$

$n = 0.98 \ mol$

$$U = \frac{3}{2} nRT$$

$$= 1.5 \times 0.98 \times 8.31 \times 300$$

$$= 3665 \longrightarrow 3700 \ [J]$$

(13) Answer

3700 J (16%)