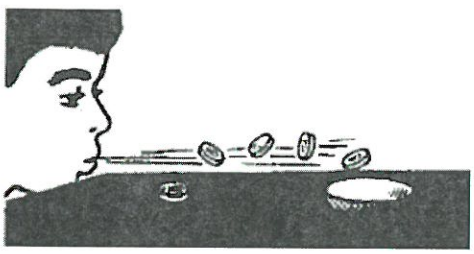
Students 8
Average 53.4 /100
Best 79.5 /100

12^{th} Grade Honor Physics (2017 – 18)

(2^{nd}Q, Exam)

(February 2, 2018)

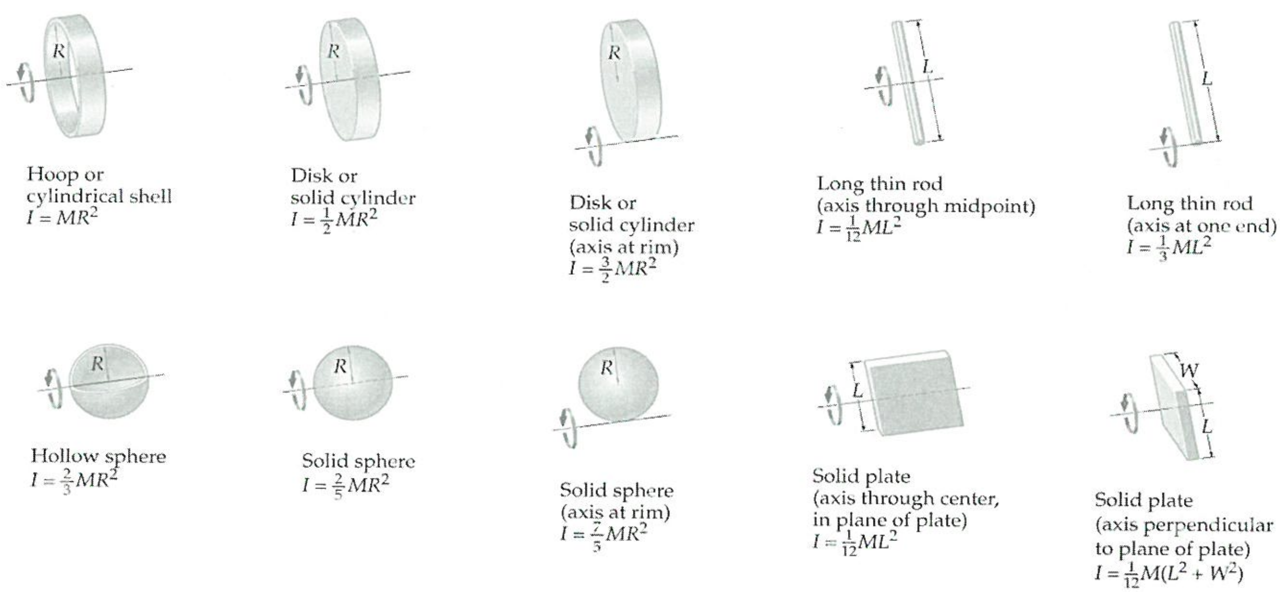
Class 12	No.	Name Solutions



In calculation problems, describe equations clearly and systematically enough to show how to solve the problems. If not enough, you won't get any point.

5 points/problem x 21 problems= 105 points(Max 100 points)

Exam	/[Total 100 points]
Lab Reports	



Atomic Mass

Name	Symbol	Atomic Mass
Hydrogen	H	1.00794(7)[2,3,4]
Helium	He	4.002602(2)[2,4]
Lithium	Li	6.941(2)[2,3,4,5]
Beryllium	Be	9.012182(3)
Boron	B	10.811(7)[2,3,4]
Carbon	C	12.0107(8)[2,4]
Nitrogen	N	14.0067(2)[2,4]
Oxygen	O	15.9994(3)[2,4]
Fluorine	F	18.9984032(5)
Neon	Ne	20.1797(6)[2,3]

Gravitational acceleration rate	$g = 9.80\ m/s^2$
Universal Gravitational Constant	$G = 6.674 \times 10^{-11}\ N \cdot m^2/kg^2$
Radius of the Earth	$R_E = 6.371 \times 10^6\ m$
Mass of the Earth	$M_E = 5.972 \times 10^{24}\ kg$
Mass of the Sun	$M_S = 1.9884 \times 10^{30}\ kg$
Radius of the Mars	$R_M = 3.39 \times 10^6\ m$
Mass of Mars	$M_M = 6.43 \times 10^{23}\ kg$
Angular speed of Earth's Rotation	$\omega = 7.292 \times 10^{-5}\ rad/s$
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	$k = 1.381 \times 10^{-23}\ J/K$
Coulomb's Law constant	$k = 8.99 \times 10^9\ N \cdot m^2/C^2$
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/(N \cdot m^2)$
Elementary Charge	$e = 1.60 \times 10^{-19}\ C$
Electron mass	$m_e = 9.11 \times 10^{-31}\ kg$
Proton mass	$m_p = 1.673 \times 10^{-27}\ kg$

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

		Density 密度 [kg/m^3]
Gold	金	19,300
Silver	銀	13,600
Iron	鉄	7,860
Sea water	海水	1,025
Water	水	1,000
Ice	氷	917
Air	空気	1.29
Helium gas	ヘリウム	0.179
Hydrogen gas	水素(気体)	0.0899

		Latent Heat of Fusion 融解潜熱 L_f [J/kg]	Latent Heat of Vaporization 蒸発潜熱 L_v [J/kg]
Water	水	3.35×10^5	22.6×10^5
Ethanol	エタノール	1.08×10^5	8.55×10^5

(1,2) A pulley in the figure at is rotating. At a given time, its angular velocity is −8.4 rad/s and its angular acceleration is −2.8 rad/s^2.
(1) Find the angular velocity after 3.0 s.
(2) How many revolutions does the pulley make during 2.0 s. (Equations)

(1) $\omega_0 = -8.4$ rad/s

$\alpha = -2.8$ rad/s^2

$\omega = \omega_0 + \alpha t$

$= -8.4 - 2.8\,t$

$= -8.4 - 2.8 \times 3.0$

$= -16.8 \longrightarrow -17$ rad/s

(2) $\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$= -8.4 \times 2.0 - \frac{1}{2} \times 2.8 \times 2.0^2$

$= -16.8 - 5.6$

$= -22.4$ rad

$= -22.4$ rad $\times \frac{1 \text{ rev}}{2\pi \text{ rad}}$

$= -3.56$ rev.

$\longrightarrow -3.6$ rev.

(1) Answer
−17 rad/s (88%)

(2) Answer
3.6 revolutions (79%)

(3) As an ice skater begins a spin, her angular speed is 3.17 rad/s. After pulling in her arms, her angular speed increases to 5.46 rad/s. Find the ratio of the skater's final moment of inertia to her initial moment of inertia.

(Equations)

$\omega = 3.17$ rad/s

$\omega' = 5.46$ rad/s

$L = L'$

$I\omega = I'\omega'$

$\frac{I'}{I} = \frac{\omega}{\omega'} = \frac{3.17}{5.46} = 0.5806$

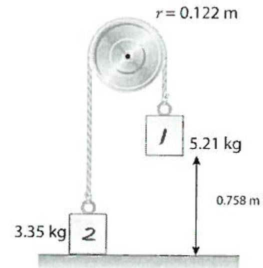
$\rightarrow 0.581$

(3) Answer

0.581

(63%)

(4) In the Atwood's machine shown in the figure are released from rest. When the 5.21-kg weight hits the ground its speed is 1.77 m/s. Find the pulley's mass.



$K = m_1 g h$

$K' = \frac{1}{2}(m_1 + m_2) v^2 + \frac{1}{2} I \omega^2$

$I = \frac{1}{2} M r^2$

$\omega = \frac{v}{r}$

$K = K' \rightarrow \quad m_1 g h = \frac{1}{2}(m_1+m_2) v^2 + \frac{1}{2} \cdot \frac{1}{2} M r^2 \cdot \frac{v^2}{r^2} + \frac{1}{2} m_2 g h$

$(m_1 - m_2) g h = \frac{1}{2}(m_1 + m_2) v^2 + \frac{1}{4} M v^2$

$M = \frac{(m_1 - m_2) g h - \frac{1}{2}(m_1+m_2) v^2}{\frac{1}{4} v^2}$

$= \frac{4(m_1 - m_2) g h}{v^2} - 2(m_1 + m_2)$

$= \frac{4 \times 1.86 \times 9.80 \times 0.758}{1.77^2} - 2(5.21 + 3.35)$

$= 17.64 - 17.12$

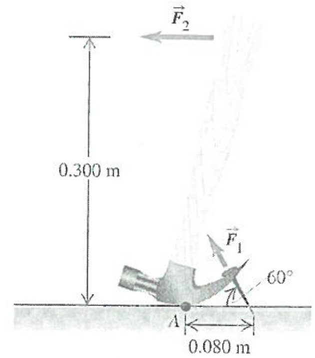
$= 0.5209 \longrightarrow 0.5$

(4) Answer

0.5 kg

(38%)

(5) A hammer is used to pull a nail out of a board. The nail is at an angle of 60° to the board, and a force $\vec{F}_1$ of magnitude 500 N applied to the nail is required. What magnitude of force $\vec{F}_2$ is required to apply the required 500-N force (F_2) to the nail?
(Equations)



$\sum \tau = 0$

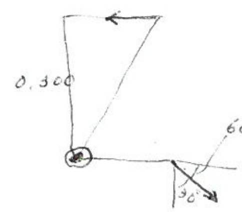
$(\sum F = 0)$

$0.300 F_2 = 0.080 \times 500 \sin 60°$

$F_2 = \frac{0.080 \times 500 \times \sin 60°}{0.300} = \frac{34.641}{0.300}$

$= 115.47$

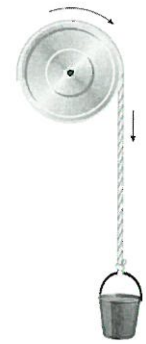
$\rightarrow 115$



(5) Answer

115 N

(41 %)



(6) A 3.85-kg bucket is attached to a disk-shaped pulley of radius 0.121 m and mass 0.742 kg. The bucket is allowed to fall.
(6-a) What is its linear acceleration?
(6-b) What is the angular acceleration of the pulley?
(Equations)

$F - mg = ma$ —①

$\tau = I\alpha$

$-rF = \frac{1}{2}Mr^2 \cdot \frac{a}{r}$

$F = -\frac{1}{2}Ma$ —②

①, ② $-\frac{1}{2}Ma - mg = ma$

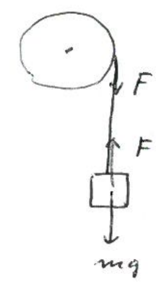
$a(m + \frac{1}{2}M) = -mg$

$a = \frac{-3.85 \times 9.80}{3.85 + \frac{1}{2}0.742} = -8.939$

$\rightarrow -8.94$

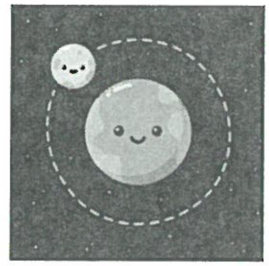
$\alpha = \frac{a}{r} = \frac{-8.939}{0.121} = -73.87$

$\rightarrow -73.9$



(6-a) Answer 8.94 m/s² downward	
(6-b) Answer 73.9 rad/s² CW	

(13 %)



(7) Assume the moon orbits the earth in a circular orbit. From the observed period of 12.3 d, calculate the distance of the moon from the center of the earth. Assume that the motion of the moon is determined solely by the gravitational force exerted on it by the earth.
(Equations)

$$m r \omega^2 = G \frac{m}{r^2} M_E$$

$$\rightarrow r^3 = \frac{G M_E}{\omega^2}$$

$$\omega = \frac{2\pi}{T}$$

$$r^3 = \frac{G M_E T^2}{4\pi^2}$$

$$G = 6.674 \times 10^{-11}$$

$$M_E = 5.972 \times 10^{24}$$

$$T = 12.3\ d \times \frac{24\ h}{1\ d} \times \frac{3.6 \times 10^3\ s}{1\ h} = 1.063 \times 10^6\ s$$

$$r^3 = \frac{6.674 \times 5.972 \times 1.130}{4\pi^2} \times 10^{-11+24+12}$$

$$= 1.1405 \times 10^{25}$$

$$= 11.405 \times 10^{24}$$

$$r = 2.251 \times 10^8\ (m)$$

$$= 2.251 \times 10^5\ (km)$$

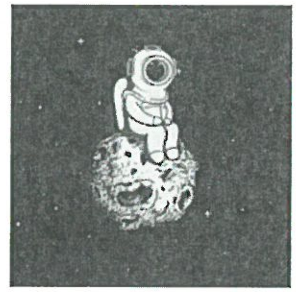
$$\rightarrow 2.25 \times 10^5\ (km)$$

(7) Answer

2.25×10^5 km

(81 %)

(8) The asteroid Dactyl, discovered in 1993, has a radius of only about 700 m and a mass of about 3.6 x 10^{12} kg. Find the escape speed for an object at the surface of Dactyl. Could a person reach this speed just by walking? (Equations)



$r = 700\ m$

$= 3.6 \times 10^{12}\ kg$

$\frac{1}{2} m v^2 - \frac{G m M}{r} = 0$

$v = \sqrt{\frac{2GM}{r}}$

$= \sqrt{\frac{2 \times 6.674 \times 10^{-11} \times 3.6 \times 10^{12}}{700}}$

$= \sqrt{0.0686 \times 10}$

$= 0.829$

$\rightarrow 0.83\ m/s$

(8) Answer

0.83 m/s

yes

(45%)

(9) What is the acceleration due to gravity on the top of Mt. Everest? The summit is about 8.80 km above sea level. (Equations)

$$g = \frac{GM_E}{r^2}$$

$$\frac{g'}{g} = \left(\frac{r}{r'}\right)^2$$

$$g' = \left\{\frac{6371 \times 10^3}{(6371 + 8.80) \times 10^3}\right\}^2 \times 9.80$$

$$= 9.80 \times 0.9986$$

$$= 9.786$$

$$\rightarrow 9.79$$

(9) Answer

9.79 m/s^2

(78 %)

(10) What mass on a spring with a spring constant of 132 N/m will oscillate with a period of 2.0 s?
(Equations)

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

$$\rightarrow m = k\left(\frac{T}{2\pi}\right)^2$$

$$= 132\left(\frac{2.0}{2\pi}\right)^2$$

$$= 13.3 \rightarrow 13$$

(10) Answer 13 kg (91%)

(11,12) The velocity of a vertically oscillating mass-spring system is given by:

$$v = (0.750 m/s) sin (4.00\ rad/s \cdot t)$$

(11) Determine the amplitude.
(12) Determine the maximum acceleration of this oscillator.
(Equations)

$$x = -A\cos\omega t$$
$$v = A\omega\sin\omega t$$
$$a = -\omega^2 x$$

$$A\omega = 0.750, \quad \omega = 4.00$$

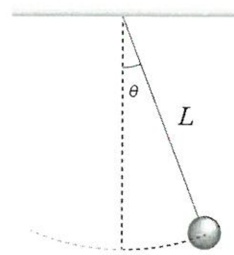
$$A = \frac{0.750}{4.00} = 0.18750 \rightarrow 0.188$$

$$a_{max} = \omega^2|A|$$
$$= 4.00^2 \times 0.1875$$
$$= 3.000$$
$$\rightarrow 3.00$$

(11) Answer 0.188 m (71%)

(12) Answer 3.00 m/s^2 (58%)

(13,14) A simple pendulum is set into small-angle motion making a maximum angle with the vertical of 5.00° Its period is 2.21 s.
(13) Determine its length.
(14-a) Determine its maximum speed.
(14-b) What is its maximum angular speed?
(Equations)

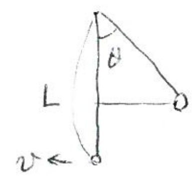


(13) $T = 2\pi\sqrt{\frac{L}{g}}$

$L = g\left(\frac{T}{2\pi}\right)^2$

$= 9.80 \times \left(\frac{2.21}{2\pi}\right)^2$

$= 1.212$



(14a) $\frac{1}{2} m v^2 = m g h$

$v = \sqrt{2gh}$

$h = L(1-\cos\theta)$

$= 1.212(1-\cos 5.00°)$

$= 4.612 \times 10^{-3}$

$v = \sqrt{2 \times 9.80 \times 4.612 \times 10^{-3}}$

$= \sqrt{9.040 \times 10^{-2}}$

$= 3.007 \times 10^{-1}$

$\rightarrow 0.301$

(14-b) $\omega = \frac{v}{r}$

$= \frac{0.3007}{1.212}$

$= 0.2481$

$\rightarrow 0.248$

(13) Answer
1.21 m

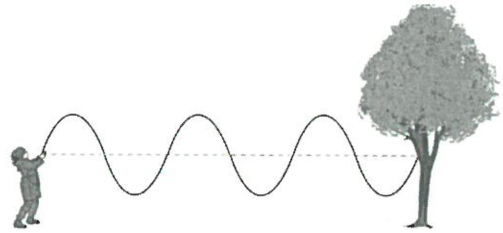
(78%)

(14-a) Answer
0.301 m/s

(14-b) Answer
0.248 rad/s

(15%)

(15~17) You are playing with the string. You hold it taut, and wiggles the end up and down sinusoidally with frequency 2.00 Hz and amplitude 0.0750 m. The wave speed is v = 12.0 m/s. At time t = 0 the end has zero displacement and is moving in the =y-direction. Assume that no wave bounces back from the far end to muddle up the pattern.



(15,16) Find the amplitude angular frequency, period, wavelength, and wave number of the wave.

(17) Find the displacement of the string at 0.200 s and at the point 3.00 m from your end.

(Equations)

$$x = A \sin 2\pi \left(\frac{x}{\lambda} - \frac{t}{T} \right)$$

$A = 0.0750$ m

$f = 2.00$ Hz $\quad \omega = 2\pi f = 12.57 \text{ rad/s} \rightarrow 12.6 \text{ rad/s}$

$T = \frac{1}{f} = 0.500$ s

$v = 12.0$ m/s $\quad v = f\lambda$

$\lambda = \frac{v}{f} = \frac{12.0}{2.00} = 6.00$ m

$k = \frac{2\pi}{\lambda} = \frac{2 \times \pi}{6.00} = 1.047 \text{ m}^{-1}$

$$x = 0.0750 \sin 2\pi \left(\frac{3}{6} - \frac{0.2}{0.5} \right)$$

$= 0.0750 \sin (2\pi \times 0.1) \text{ rad})$

$= 0.0750 \sin 0.2\pi \times \frac{180}{\pi}$

$= 0.0750 \sin 36^\circ$

$= 0.04408$

$\rightarrow 0.0441$

(15) Answer	
Amplitude	0.0750 m
Angular frequency	12.6 rad/s
Period	0.500 s

(65%)

(16) Answer	
Wavelength	6.00 m
Wave number	1.05 rad/m

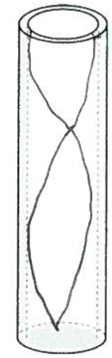
(41%)

(17) Answer

0.0441 m

(16%)

(18) (18-a) Draw the shape of the standing wave of the third harmonic frequency in a column of air that is open at one end, with a transverse-wave expression.
(18-b) Find the wavelength and frequency of the third harmonic frequency for the column of 0.550 m length.
(Equations)



$$\frac{\lambda}{4} \times 3 = 0.550$$

$$\lambda = 0.550 \times \frac{4}{3} = 0.7333 \rightarrow 0.733$$

$$f = \frac{v}{\lambda} = \frac{343}{0.7333} = 467.73 \rightarrow 468$$

(18-a) Answer	
Illustrate in the figure.	
(18-b) Answer Wavelength	0.733 m
Frequency	468 Hz

(49%)

(19) A garage lift has input and lift (output) pistons with diameters of 10 cm and 30 cm, respectively. The lift is used to hold up a car with a weight of 1.4 x 10^4 N.
(19-a) What is the magnitude of the force on the input piston?
(19-b) What pressure is applied to the input piston?
(Equations)

$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \qquad A_1 = \pi(0.05)^2 \qquad A_2 = \pi(0.15)^2$$

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

$$= 1.4\times10^4 \times \frac{\pi(0.05)^2}{\pi(0.15)^2}$$

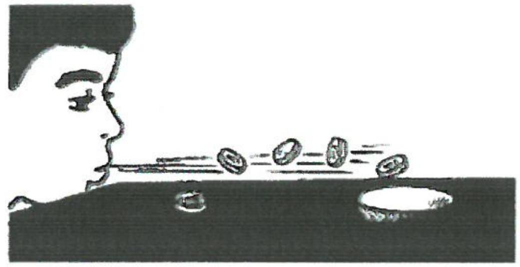
$$= 1.4\times10^4 \times 0.1111$$

$$= 1.56\times10^3 \rightarrow 1.6\times10^3$$

$$P = \frac{1.4\times10^4}{\pi\times(0.15)^2} = 19.8\times10^4 \rightarrow 2.0\times10^5$$

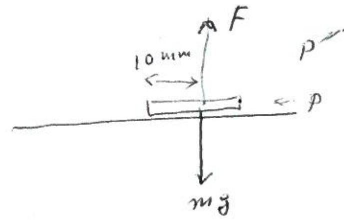
(19-a) Answer	1.6×10^3 N
(19-b) Answer	2.0×10^5 Pa

(34%)



(20) In a dramatic class demonstration, Genseki blows hard across the top of an aluminum one-yen coin that is at rest on a level desk. By doing this at the right speed, he can get the coin to accelerate vertically, into the airstream, and then deflect it into a tray, as shown in the figure. Assuming the diameter of the coin is 20.0 mm and it has a mass of 1.00 g, what is the minimum airspeed needed to lift the penny off the tabletop? Assume the air under the coin remains at rest.

(Equations)



$$P + \frac{1}{2}\rho v^2 = P' + \frac{1}{2}\rho v'^2$$

$$\frac{1}{2}\rho v^2 = 0$$

$$v' = \sqrt{\frac{2(P-P')}{\rho}}$$

$$P - P' = \frac{F}{A} = \frac{mg}{A} = \frac{1.00\times10^{-3}\times 9.80}{\pi(10\times10^{-3})^2}$$

$$= 31.19 \times10^{-3}\times10^{-3}\times10^{6} = 31.19\ (Pa)$$

$$\rho = 1.29$$

$$v' = \sqrt{\frac{2\times 31.19}{1.29}}$$

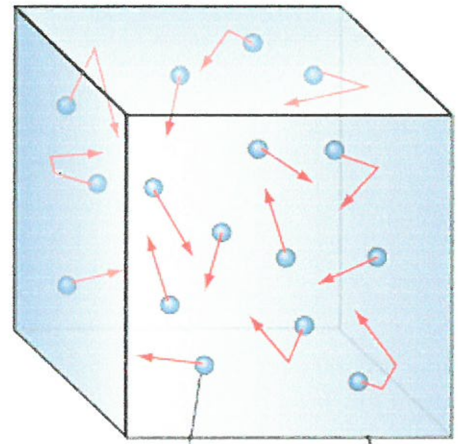
$$= 6.954$$

$$\rightarrow 6.95$$

(20) Answer

6.95 m/s

(1 %)



(21) What is the temperature of carbon dioxide gas molecules whose rms speed is 456 m/s?
(Equations)

$$PV = \frac{N}{3} m \overline{v^2}$$

$$PV = NkT$$

$$\therefore NkT = \frac{N}{3} m \overline{v^2}$$

$$T = \frac{m \overline{v^2}}{3k}$$

$$m = \frac{(12.0 + 32.0) \times 10^{-3}}{6.022 \times 10^{23}}$$

$$\overline{v^2} = 456^2$$

$$k = 1.381 \times 10^{-23}$$

$$T = \frac{44 \times 10^{-3}}{6.022 \times 10^{23}} \times 456^2 \times \frac{1}{3} \times \frac{1}{1.381 \times 10^{-23}}$$

$$= 366.7 \longrightarrow 367$$

(21) Answer

367 K

(26%)

Opinions