Student 8
Average 20.3 /50
Best 42.0 /50

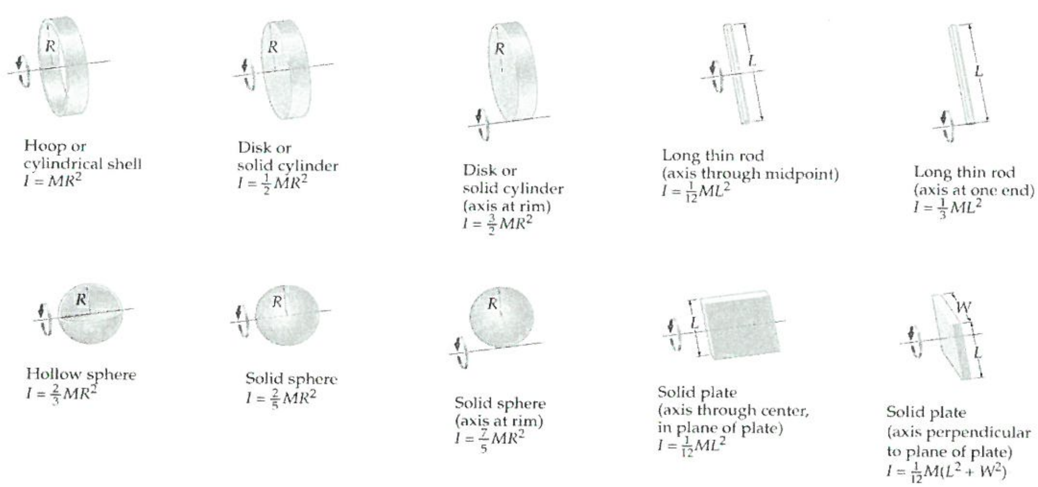
12th Physics (2017 – 18)

(1stQ, #2 Mini Test)

Class	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 points.

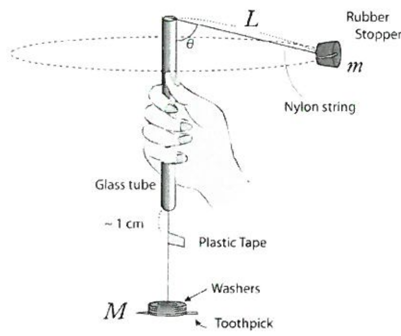
Gravitational acceleration rate	g = 9.80 m/s^2
Universal Gravitational Constant	G = 6.67 x 10^{-11} N・m^2/kg^2
Mean radius of the Earth	6371.0 km
Volume of the Earth	1.083 x 10^{12} km^3
Mass of the Earth	5.972 x 10^{24} kg
Angular velocity of the Earth	7.272 x 10^{-5} rad/s



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

/[Total 50 pt]

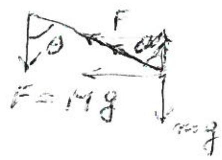
(1~3) The figure shows the lab of circular motion you carried out recently. The mass of washers is M = 30.0 g, the mass of the rubber stopper is m = 3.50 g, the length L = 50.0 cm.



(1) Find the magnitude of the angle θ.
(2) Find the period of this circular motion.
(3) Find the speed of the rubber stopper.

(Equations)

(1) $M\cancel{g}\cos\theta = m\cancel{g}$



$\theta = \cos^{-1}\left(\frac{m}{M}\right)$

$= \cos^{-1}\left(\frac{3.50}{30.0}\right) = 83.30^\circ \longrightarrow 83.3^\circ$

(2) $Mg\sin\theta = mr\omega^2$ $\quad T = \frac{2\pi}{\omega}$

$r = L\sin\theta$

$Mg\cancel{\sin\theta} = mL\cancel{\sin\theta}\,\omega^2$ $\quad \omega = \sqrt{\frac{Mg}{mL}} = \sqrt{\frac{30.0\times9.80\times10^{-3}}{3.50\times10^{-3}\times0.50}}$

$= 12.961$ (rad/s)

$T = \frac{2\pi}{12.961} = 0.4847 \rightarrow 0.485$ (s)

(3) $v = r\omega$

$= 0.50\sin 83.30^\circ \times 12.961$

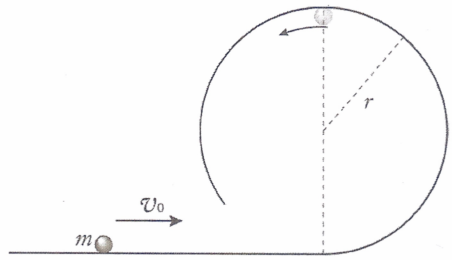
$= 6.436 \rightarrow 6.44$ (m/s)

(1) Answer
83.3° (50%)

(2) Answer
0.485 s (27%)

(3) Answer
6.44 m/s (39%)

(4) A 45 g particle is moving at the bottom of a frictionless circular loop track with a radius of r = 38 cm. Find the initial speed of the particle, v_0, which enables the particle to go up to the top of the loop.
(Equations)



Energy $\frac{1}{2}\cancel{m}v_0^2 = \cancel{m}g \cdot 2r + \frac{1}{2}\cancel{m}v^2$

$\rightarrow v_0^2 = 4gr + v^2$ —— ①

Circular motion $N + mg = m\frac{v^2}{r}$, $N = 0$

$v^2 = rg$ —— ②

$\therefore v_0^2 = 5gr$

$v_0 = \sqrt{5gr} = \sqrt{5 \times 9.80 \times 0.38}$

$= 4.315 \longrightarrow 4.3$

(4) Answer
4.3 m/s

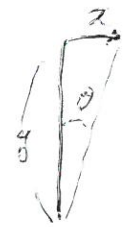
(50%)

10/19/2017 By Tohei Moritani

(5) At a game held in Boston (located at 42.2° north latitude), Daisuke Matsuzaka (P) threw a fastball at speed of 150 km/h. Find the magnitude and direction of the drift of the ball at the batter (B), standing at 18 m apart from the pitcher, due to the rotation of the Earth. Assume the effect of air is negligible.

(Equations)

$$150\ \mathrm{km/h} = \frac{150}{3.6}\ \mathrm{m/s} = 41.67\ \mathrm{m/s}$$



$$t = \frac{d}{v} = \frac{18}{41.67} = 0.432\ (s)$$

$$x = y \cdot \underbrace{\theta}_{\sin\varphi} = y \cdot \omega t \sin\varphi$$

$$= 18 \times 7.272 \times 10^{-5} \times 0.432 \sin 42.2° = 37.99 \times 10^{-5}\ \mathrm{m}$$

$$= 0.3799\ \mathrm{mm}$$

(5) Answer
0.38 mm
to right

(6%)

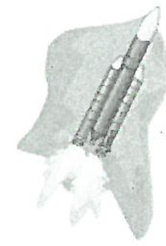
(6) – (8)

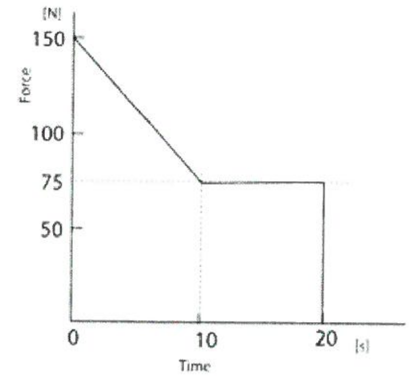
(6) How long does it take a net force of 100 N acting on a 50.0-kg rocket to increase its speed from 100 m/s to 150 m/s?

(7) After that, the force is acted in the same direction as the above and changes as shown in the figure. Determine the magnitude of the final velocity.

(8) When the rocket is traveling at 250 m/s, it ejected fuel of 15.00 kg momentarily and backward. The relative velocity between the rocket and the fuel is 55.0 m/s. In this process, what is the final speed of the rocket for the observer in space.

(Equations)





(6) $I = P \qquad F\Delta t = mv' - mv$

$$\Delta t = \frac{m(v'-v)}{F} = \frac{50.0(150-100)}{100}$$

$$= 25.00 \rightarrow 25\,(s)$$

(7) $I = \frac{1}{2}(150-75)\times 10 + 75 \times 20$

$$= 375 + 1500 = 1875$$

$$I = mv' - mv \rightarrow v' = \frac{I + mv}{m} = \frac{1875 + 50.0\times 150}{50.0}$$

$$= 187.5 \rightarrow 190\ (m/s)$$

(8) $MV_0 = mv + (M-m)V$ 15.0 kg 50.0 250 m/s

v V 2 1 15.0 50.0 − 15.0

$50 \times 250 = 15v + 35V$ —①

$v_{21} = v_2 - v_1$

$-55 = v - V$ —②

② : $v = V - 55$

$12500 = 15(V-55) + 35V$

$12500 + 825 = (15+35)V$

$$V = \frac{12500 + 825}{50} = 266.5$$

$\rightarrow 270$ m/s

(6) Answer	25 s

(81%)

(7) Answer	190 m/s

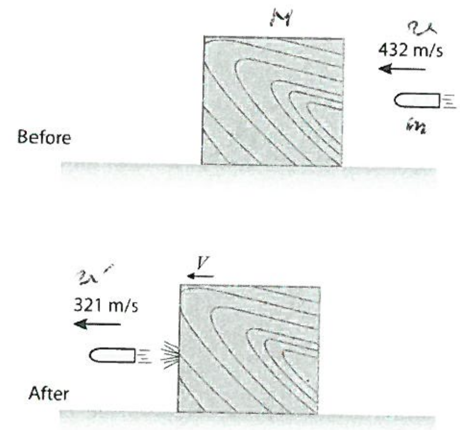
(188)

(42%)

(8) Answer	270 m/s

(28%)

(9) A 10.0 g bullet moving horizontally at 432 m/s penetrates a 3.00 kg wood block resting on a horizontal surface. If the bullet slows down to 321 m/s after emerging from the block, what is the speed of the block immediately after the bullet emerges.
(Equations)



$m v = m v' + M V'$ $\quad V'$?

$V' = \dfrac{m(v - v')}{M}$

$= \dfrac{0.010 \times (432 - 321)}{3.00}$

$= 0.3700$ (m/s)

$\rightarrow 0.370$ (m/s)

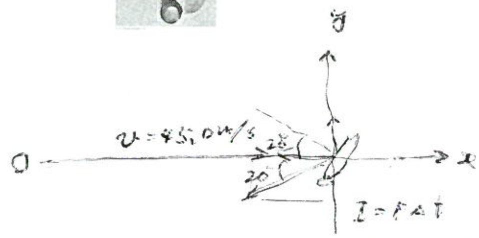
(9) Answer

0.370 m/s

(55%)

(10) A 0.144 kg baseball is moving toward home plate with a speed of 45.0 m/s when it bunted (hit softly). The bat exerts an average force of 6.60 x 10^3 N on the ball for 1.40 ms (1.40 x 10^{-3} s). When the average force is directed toward 20° left from the direction to the pitcher, what is the final velocity (the direction and the speed) of the ball?

(Equations)



$I = F\Delta t = 6.60\times10^{3} \times 1.40\times10^{-3} = 9.24$ N·s

$$\vec{F}\Delta t = m\vec{v}\,' - m\vec{v} \qquad \vec{v}\,'?$$

$$F_x \Delta t = m v_x' - m v_x$$

$$F_y \Delta t = m v_y' - m v_y$$

$$v_x' = \frac{F_x \Delta t}{m} + v_x = 45.0 + \frac{-9.24\cos 20^\circ}{0.144}$$

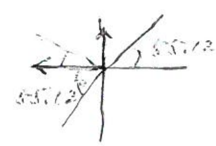
$$= 45.0 - 60.30 = -15.30$$

$$v_y' = \frac{F_y \Delta t}{m} + v_y = 0 + \frac{-9.24\sin 20^\circ}{0.144} = -21.95$$

$$v' = \sqrt{v_x'^2 + v_y'^2} = \sqrt{15.30^2 + 21.95^2} = 26.76 \rightarrow 27 \text{ m/s}$$

$$\theta = \tan^{-1}\left(\frac{v_y'}{v_x'}\right) = \tan^{-1}\left(\frac{-21.95}{-15.30}\right) = -55.12^\circ$$

$$\rightarrow -55^\circ$$



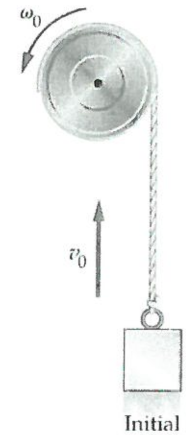
(10) Answer

27 m/s

toward 55° left from the direction to the pitcher

(38%)

(11,12) A pulley rotating in CCW direction is attached to a mass suspended from string. The pulley's initial angular velocity is ω_0 = 5.40 rad/s. The mass causes the pulley's angular velocity to decrease with a constant acceleration α = -2.30 rad/s^2.
(11) How long does it take before the angular velocity of the pulley is equal to – 5.5 rad/s?
(12) Through what revolutions does the pulley turn during this time?
(Equations)



(11) $\omega = \omega_0 + \alpha t$

$t = \frac{\omega - \omega_0}{\alpha} = \frac{-5.5-5.40}{-2.30} = 4.738$

$\rightarrow 4.7$

(12) $\omega^2 - \omega_0^2 = 2\alpha\theta$

$\theta = \frac{(-5.5)^2-(5.40)^2}{2\times(-2.30)} = -0.2370$ rad

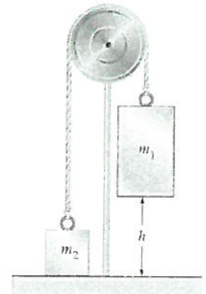
$\frac{-0.2370}{2\pi} = -0.0376$ rev

$\boxed{(11)\ \ 4.7\ s}$ (48%)

$\boxed{(\cancel{11})\ \text{Answer}\ 12\ \ 0.038\ \text{rev}}$ (33%)

(12) Answer

(13) The two masses (m_1 = 5.0 kg and m_2 = 3.0 kg) in the Atwood machine shown in the figure are released from the rest, with m_1 at a height of 0.75 m above the floor. When m_1 hits the ground its speed is 1.8 m/s. The pulley is a uniform disk with a radius of 12 cm. Find the pulley's mass.
(Equations)



Before $E = m_1 g h = 5.0 \times 9.80 \times 0.75$

$= 36.75$ (J)

After $E = \frac{1}{2}(m_1+m_2)v_1^2 + m_2 g h + \frac{1}{2} I \omega^2$

$I = \frac{1}{2} M R^2$, $\omega = \left(\frac{v_1}{R}\right)$

$E = \frac{1}{2}(m_1+m_2)v_1^2 + m_2 g h + \frac{1}{4} M v_1^2$

$= \frac{1}{2}(8.0) \times 1.8^2 + 3.0 \times 9.80 \times 0.75 + \frac{1}{4} \times 1.8^2 M$

$= 35.01 + 0.810 M$

$M = \frac{36.75 - 35.01}{0.810} = \frac{1.75}{0.810} = 2.148$

(13) Answer

2 kg

(11%)

 10/19/2017 By Tohei Moritani