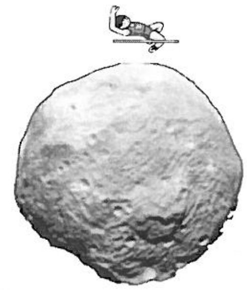
12th Physics (2018 – 19)

(2nd Q, #1 Mini Test)

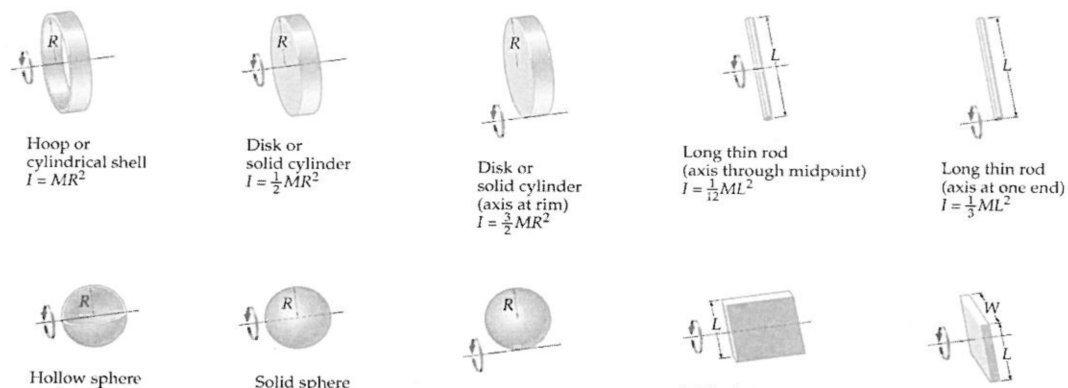


Name Solutions

In calculation problems, clearly and systematica[lly] to solve the problems. **won't get any points.**

Gravitational acceleration rate	$g = 9.80\ m/s^2$
Universal Gravitational Constant	$G = 6.67 \times 10^{-11}\ N \cdot m^2/kg^2$
Radius of the Earth	$R_E = 6.37 \times 10^6\ m$
Mass of the Earth	$M_E = 5.97 \times 10^{24}\ kg$
Mass of the Sun	$M_{\odot} = 1.9884 \times 10^{30}\ kg$
Mass of Mars	$M = 6.39 \times 10^{23}\ kg$
Angular speed of Earth's Rotation	$\omega = 7.29 \times 10^{-5}\ rad/s$

Radius of



Hoop or cylindrical shell $I = MR^2$

Disk or solid cylinder $I = \frac{1}{2}MR^2$

Disk or solid cylinder (axis at rim) $I = \frac{3}{2}MR^2$

Long thin rod (axis through midpoint) $I = \frac{1}{12}ML^2$

Long thin rod (axis at one end) $I = \frac{1}{3}ML^2$

Hollow sphere $I = \frac{2}{3}MR^2$

Solid sphere $I = \frac{2}{5}MR^2$

Solid sphere (axis at rim) $I = \frac{7}{5}MR^2$

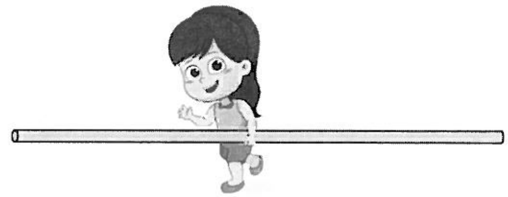
Solid plate (axis through center, in plane of plate) $I = \frac{1}{12}ML^2$

Solid plate (axis perpendicular to plane of plate) $I = \frac{1}{12}M(L^2 + W^2)$

5 pt/question x 10 questions = 50 pt Max 50 pt

/ [Total 50 pt]

(1) A person holds a uniform rod horizontally at its center. The rod has a length 3.05 m and mass 6.42 kg. Find the torque the person must exert on the rod to give it an angular acceleration of 0.402 rad/s^2.



$$\Sigma \tau = I \alpha$$

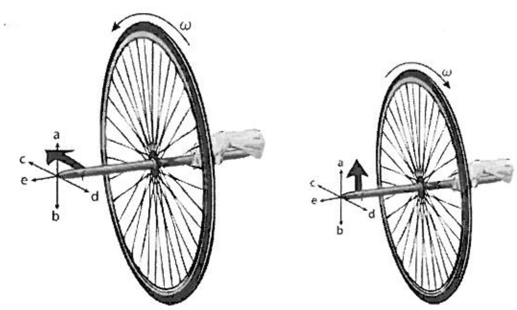
$$= \frac{1}{12} M L^2 \alpha$$

$$= \frac{1}{12} \times 6.42 \times 3.05^2 \times 0.402$$

$$= 2.001 \longrightarrow 2.00$$

(1) Answer
2.00 N·m

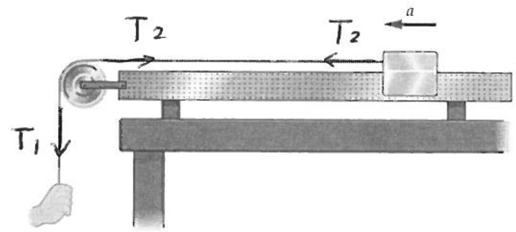
(2) In a physics demonstration, you support the axle of a rotating bicycle wheel, as shown. When you are going to move to the direction shown by an arrow, the wheel shows a different movement. Find the direction from a ~ f.



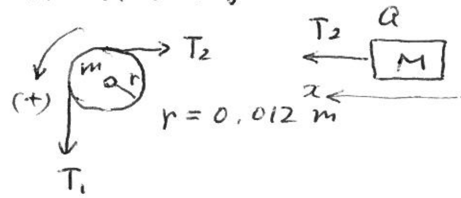
2-a 2-b

(2-a) Answer	(2-b) Answer
b	d

(3) A 0.32-kg cart on a horizontal air track is attached to a string. The string passes over a disk-shaped pulley of mass 0.081 kg and radius 0.012 m and is pulled vertically downward with a constant force of 1.2 N.
(3-a) Find the tension in the string between the pulley and the cart.
(3-b) Find the acceleration of the cart.
[Equations]



$m = 0.080\ kg$ $M = 0.32\ kg$



$$T_2 = Ma \quad —①$$

$$\sum \tau = I\alpha \quad —②$$

$$\sum \tau = rT_1 - rT_2 \quad —③$$

$$I = \frac{1}{2}mr^2 \quad —④$$

$$a = r\alpha \quad —⑤$$

② ~ ⑤ $\cancel{r}T_1 - \cancel{r}T_2 = \frac{1}{2}m\cancel{r^2}\left(\frac{a}{\cancel{r}}\right) \quad —②'$

①, ②' $T_1 - T_2 = \frac{1}{2}m \cdot \frac{T_2}{M} \rightarrow \left(\frac{m}{2M} + 1\right)T_2 = T_1$

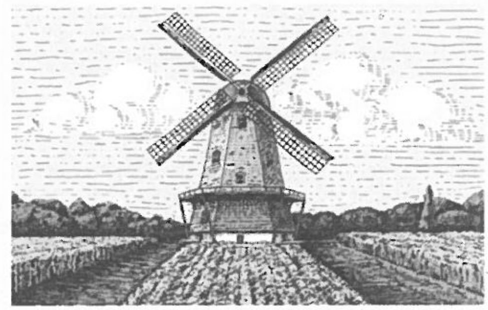
$T_1 = 1.2N$

$$T_2 = \frac{1.2}{\frac{0.080}{2 \times 0.32} + 1} = 1.067 \longrightarrow 1.1$$

$$a = \frac{T_2}{M} = \frac{1.067}{0.32} = 3.33$$
$\rightarrow 3.3$

(3) Answer	
(3-a): Tension	1.1 N
(3-b): Acceleration	3.3 m/s^2

(4) A windmill has an initial angular momentum of 7800 kg・m²/s. The wind picks up, and 6.54 s later the windmill's angular momentum is 9800 kg・m²/s. What was the torque acting on the windmill, assuming it was constant during this time?
[Equations]



$$L_0 = 7800 \quad kg\cdot m^2/s$$
$$L = 9800 \quad ''$$

$$\Sigma\tau = \frac{\Delta L}{\Delta t} = \frac{9800-7800}{6.54} = 305.8 \longrightarrow 306$$

(4) Answer

306 N・m

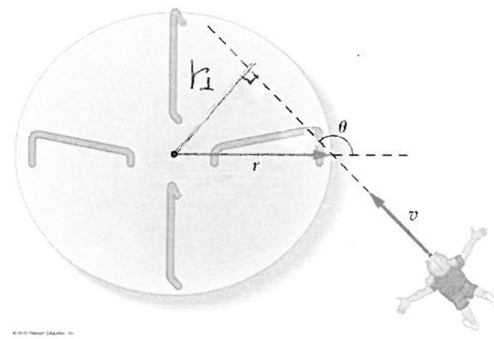
(5) As in figure skater begins a spin, her angular speed is 3.56 rad/s. After pulling her arms, her angular speed increases to 6.03 rad/s. Find the ratio of the skater's final moment of inertia to her initial moment of inertia.

$$I_i \omega_i = I_f \omega_f$$
$$\frac{I_f}{I_i} = \frac{\omega_i}{\omega_f} = \frac{3.56}{6.03} = 0.5903 \longrightarrow 0.590$$

(5) Answer

0.590

(6) A disk-shaped merry-go-round of radius r = 3.21 m and mass 175 kg rotates freely with an angular speed of 0.641 rev/s. A 59.4-kg person heads toward the rim in the direction $\theta = 145°$ indicated and then jumps onto the rim at 3.41 m/s. What is the final angular speed of the merry-go-round?



$$L_i = L_f$$

$$L_i = r m v \sin\theta + I\omega_i \quad \text{— ①}$$

$r = 3.21$ m , $\theta = 145°$

$m = 59.4$ kg

$v = 3.41$ m

$$I = \frac{1}{2}Mr^2 = \frac{1}{2} \times 175 \times 3.21^2$$

$$= 901.6$$

$$\omega_i = 0.641 \text{ rev/s}$$

$$= 0.641 \times 2\pi \text{ rad/s}$$

$$= 4.359 \text{ rad/s}$$

$$L_i = 3.21 \times 59.4 \times 3.41 \sin 145° + 901.6 \times 4.208$$

$$= 372.9 + 3631.72 = 4004.6$$

$$L_f = (I + mr^2)\omega = (901.6 + 59.4 \times 3.21^2)\omega$$

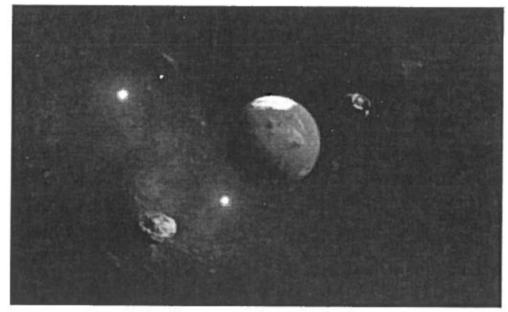
$$= 1514\ \omega$$

$$\omega = \frac{4004.6}{1514} = 2.64505 \rightarrow 2.65$$

(6) Answer

2.65 rad/s

(7) Phobos, one of the moon of Mars, orbits at a distance of 9378 km from the center of the red planet. What is the orbital period of Phobos?



$$G\frac{M\cancel{m}}{r^2} = \cancel{m}r\left(\frac{2\pi}{T}\right)^2$$

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

$$= 4\pi^2\frac{(9.378\times10^6)^3}{6.67\times10^{-11}\times6.39\times10^{23}}$$

$$= 4\pi^2\frac{9.378^3}{6.67\times6.39}\times10^{18+11-23}$$

$$= 4\pi^2\times19.35\times10^6$$

$$T = 2\pi\sqrt{19.35}\times10^3 = 2.764\times10^4\ (s)$$

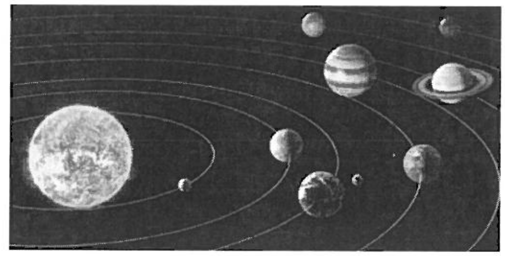
$$\approx 460.7\ (min)$$

$$= 7.679\ (h) \rightarrow 7.68\ (hr)$$

(7) Answer

7.68 hr

(8) Several meteorites found Antarctica are believed to have come from Mars. Some of them contain fossils of ancient life on Mars. Meteorites from Mars are thought to get to Earth by being blasted off the Martian surface when a large object crashes into the planet. What speed must a rock have to escape Mars?



Conservation of mechanical energy

$$\frac{1}{2}\cancel{m}v^2 - \frac{GM\cancel{m}}{r} = 0$$

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

$$= \sqrt{\frac{2 \times 6.67 \times 10^{-11} \times 6.39 \times 10^{23}}{3.40 \times 10^{6}}}$$

$$= \sqrt{25.07 \times 10^{6}}$$

$$= 5.007 \times 10^{3} \quad (m/s)$$

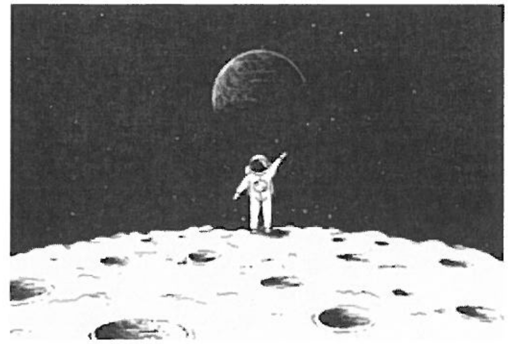
$$\rightarrow 5.01 \times 10^{3} \; (m/s)$$

(8) Answer

5.01 km/s
or larger

m

(9) The acceleration rate g at the surface of the Moon is 1.62 m/s2 and its radius is 1.74 x 10^6 km. Find the mass of the Moon assuming it is a homogeneous sphere.



$$F = G\frac{M}{R^2}m = mg$$

$$g = \frac{GM}{R^2}$$

$$M = \frac{gR^2}{G}$$

$$= \frac{1.62 \times (1.74 \times 10^6)^2}{6.67 \times 10^{-11}}$$

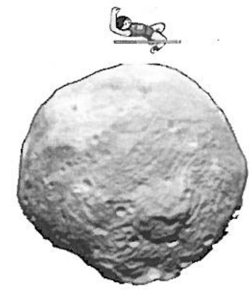
$$= 0.7353 \times 10^{23}$$

$$\rightarrow 7.35 \times 10^{22}$$

(9) Answer

7.35×10^{22} kg

(10) On Earth, a player can jump vertically and rise 2.00 m high. What is the radius of the largest spherical asteroid from which this player could escape by jumping straight upward? Assume the density of the asteroid is 3500 kg/m^3.



Conservation of mechanical energy

$$\frac{1}{2}\cancel{m}v_0^2 - G\frac{\cancel{m}M}{R} = 0$$

$$\frac{1}{2}\cancel{m}v_0^2 = \cancel{m}gh$$

$$\therefore\ gh - \frac{GM}{R} = 0$$

$$\rho = 3500 = \frac{M}{V} = \frac{M}{\frac{4}{3}\pi R^3}$$

$$M = \frac{4}{3}\pi R^3 \cdot 3500$$

$$gh = \frac{GM}{R} = \frac{G}{\cancel{R}}\cdot\frac{4}{3}\pi R^{\cancel{3}\,2}\times 3500$$

$$R = \sqrt{\frac{3\times 9.80\times 2.00}{4\pi\times 3500\times 6.67\times 10^{-11}}}$$

$$= \sqrt{2.004\times 10^{11}}$$

$$= \sqrt{20.04}\times 10^{3}$$

$$\fallingdotseq 4.477\times 10^{3}\ (m)$$

(10) Answer

4.48 km