Rotational Motion - Page #1

Kathleen Boyce

11. $K = \frac{1}{2} I \omega^2$ $I = 0.35$ $\omega = \frac{100\pi \text{ rad}}{7 s} = 44.9 \frac{rad}{s}$ 1 revolution = 2π radians

$K = \frac{1}{2}(0.35)(44.9)^2 = \boxed{352 J}$

12. a) ~~Same angular speed~~ b) 2

c) $a_c = \omega^2 r = \frac{v_t^2}{r} = 2$ (same angular velocity) d) +z e) −y

13. angular, gyroscopes, precess, are not rotating

15. a) Angular acceleration of the pulley is nonzero

b) Cord's tension on the right side of the pulley is higher than on the left side

6. a) Positive x-direction b) $F_{net} = 4f$ c) $F_N = \frac{mg}{4}$

$\tau_{net} = I\alpha = (fr) - T$ $I = k m_w r^2 \rightarrow k m_w r \alpha = f - \frac{T}{r}$

17. Shell, liquid, solid, stops entirely

18. Work + torque (N·m) and rotational KE + translational KE (J)

10. Start rotating in the opposite direction of the blade rotation

12. a) Weight of the wheel, normal force from the axle, tension in the string

b) II only c) $I\alpha = rT$ d) $mg - T = ma$ e) $\frac{a}{r} = \alpha$

f) $I\left(\frac{a}{r}\right) = rT$ $T = mg - ma$ $I\left(\frac{a}{r}\right) = r(mg - ma) = \frac{r^2}{a}(mg - ma)$

$I = \frac{mr^2 (g-a)}{a}$ g) $r = 0.312$ m h) Frame 45 i) d vs. $0.5t^2$ graph

Frame	$0.5t^2$	d (m)
92		0.05
111	0.0031337	0.1
126	0.00198312 5	0.15
138	0.00125	0.2
149	0.0010563	0.25
159	0.000868	0.3
168	0.000703	0.35

$\left(\text{Frame \#} \cdot \frac{1 s}{240 \text{ frames}}\right)^2 \cdot 0.5$ k) $I\alpha = rT$ $\alpha = \frac{a}{r}$

$\frac{d_2 - d_1}{0.5t_2^2 - 0.5t_1^2}$ $\frac{(176-45)^2 \cdot 0.5}{0.4} \Rightarrow a = 2.67 \frac{m}{s^2}$ $I\frac{a}{r} = rT$

$I = \frac{r^2 T}{a}$

$I = \frac{mr^2 (g-a)}{a} = 0.0393$ $I = kmr^2$

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13. a) Increases the day b) More mass at the equator = greater rotational inertia and smaller rotational speed of Earth

14. It begins to rotate counterclockwise (conservation of angular momentum)

15. Short calf / long thigh

16. $\alpha_A = 2\alpha_B$ because $T_B = 2T_A$ and $I_B = 4I_A$

17. All of the above

20. a) x position vs. time = Graph F b) Angular position = Graph A

c) y-velocity = Graph F d) Angular velocity = Graph C

21. a) B > C > A = F > D = E (Angular velocity) b) A = B = C = D = E = F (Angular acceleration)

22. He spins slower (conservation of angular momentum)

23. a) $\frac{0.6}{0.5} > \frac{0.4}{0.3} > \frac{0.4}{0.2} = \frac{0.2}{0.1} = \frac{0.8}{0.4} > \frac{0.6}{0.2}$

b) B = E > C > F = A > D (Linear/angular acceleration) c) B > C > F > A = E = D (Linear/radial acceleration)

24. is not attached, axis of rotation, non-zero, torque

27. Center of mass closer to the rope + increases rotational inertia

28. Translation, gravity, translation

30. Yes if the mass is distributed farther from the center

32. Pushing at the center of mass causes greater translational acceleration

33. Increases the day

35. a) Radians per second, degrees per second, revolutions per second

b) $v = 8.50 \frac{m}{s}$ c) $K = \frac{1}{2}(18)(8.5^2) = 650\text{ J}$ d) $K = \frac{1}{2}I\omega^2$

$650.25 = \frac{1}{2}I(34)^2$

$I = 1.13\text{ kg}\cdot\frac{m}{s}$

36. Ratio is constant at 2.5

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14. a) $I_2 > I_4 > I_3 = I_1$ b) Closer to, closer to

16. $F_{net} = 4f$ $N = \frac{mg}{4}$ $\tau_{net} = I\alpha = (fr) - \tau$

$km_w r\alpha = f - \frac{\tau}{r}$ $\Sigma F = ma$ $\Sigma \tau = I\alpha = \alpha mr^2$

$\tau = rf$ $4f = ma$ $f = \frac{\tau}{r} = \frac{ma}{4}$ $a = \frac{4\tau}{mr}$

↑ of each wheel

19. a) Initial Momentum $= \omega_i I_t$ Final Momentum $= \omega_f (I_t + I_r)$

$\omega_i I_t = \omega_f (I_t + I_r)$ $\omega_f = \frac{\omega_i I_t}{(I_t + I_r)}$

b) $K_i = \frac{1}{2} I_t \omega_i^2$ $K_f = \frac{1}{2}(I_t + I_r)(\omega_f)^2$ $I_t = \frac{2K_i}{\omega_i^2}$

$K_f = \frac{1}{2}(I_t + I_r)\left(\frac{\omega_i I_t}{(I_t + I_R)}\right)^2$ $K_f = \frac{1}{2}\left(\frac{2K_i}{\omega_i^2} + I_r\right)\left(\frac{\omega_i I_t}{(I_t + I_R)}\right)^2$

$K_f = \frac{K_i I_t}{(I_t + I_R)}$

11. a) Total mass, shape / density of the object, location of the axis of rotation = moment of inertia

b) I_a = undefined (no axis of rotation) c) $I_{a,x} = mr^2$ d) $I_{a,y} = 9mr^2$

e) $I_y = 2mr^2 + 9mr^2 = 11mr^2$ f) $K = 5.5mr^2\omega^2$

g) $v_a = 3\omega r$ $K_A = \frac{9}{2}m(\omega r)^2$ h) $K_B = \frac{2}{2}m(\omega r)^2 = m(\omega r)^2$ i) $K = \frac{11m(\omega r)^2}{2}$

18. $F = ma = mg - T$ $\tau = rF\sin(\phi) = -Tr$ $\frac{1}{2}mr\alpha = -T$ $\alpha = -\frac{a}{r}$

$\alpha = \frac{\frac{2}{3}g}{r}$

19. $L = I\omega$ $L_i = L_f$ $I_1\omega_o = (I - I_1)\omega_o$

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~~125.~~ Larger torque + cyclist pedals more frequently

~~126.~~ $I = mr^2$ $C = F > B > A = E > D$

~~129.~~ a) $I = (m_1 + m_2)\left(\frac{\ell}{2}\right)^2$ $\tau = g(m_1 - m_2)\frac{\ell}{2}$

$\Sigma\tau = I \cdot \alpha$ $\alpha = \frac{\tau}{I} = \frac{g(m_1 - m_2)\frac{\ell}{2}}{(m_1 + m_2)\left(\frac{\ell}{2}\right)^2}$

b) Counterclockwise with positive angular acceleration

c) Torque is the same

Moment of inertia: $M_{bar}\frac{L^2}{12} + (m_1 + m_2)\left(\frac{\ell}{2}\right)^2$ $\alpha = \frac{g(m_1 - m_2)\frac{\ell}{2}}{M_{bar}\frac{L^2}{12} + (m_1 + m_2)\left(\frac{\ell}{2}\right)^2}$

d) Counterclockwise + positive angular acceleration

~~131.~~ a) $\frac{500 \text{ revolutions}}{\text{min}} \cdot \frac{2\pi \text{ rad}}{1 \text{ rev}} \cdot \frac{1 \text{ min}}{60 \text{ s}} = \frac{52.35 \text{ rad}}{2.6 \text{ s}} = \alpha = 20.1 \frac{\text{rad}}{\text{s}}$

b) $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 = 52.35(2.6) + \frac{1}{2}(20.1)(2.6^2) = 136 - 67.9$ 68 !

$68.1 \text{ rad} \cdot \frac{1 \text{ rev}}{2\pi \text{ rad}} =$ **10.8 revolutions**

~~134.~~ $m = 0.1$ kg $r = 0.4$ m $T_i = 6.0$ s $r_f = 0.3$ m $T_f = ?$ $\omega = \frac{v}{r} = \frac{2\pi r}{T}$

$L_i = L_f$ $I_i\omega_i = I_f\omega_f$ $\frac{mr_i^2 2\pi}{T_i} = \frac{mr_f^2 2\pi}{T_f}$

$T_f = \frac{r_f^2 T_i}{r_i^2} = \frac{(0.3^2)(6.0)}{(0.4^2)} =$ **3.4 s**

19. $L_i = L_f$ $I_1\omega_0 = (I + I_1)\omega_{student} - I_1\omega_0$

$\omega_{student} = \frac{2I_1\omega_0}{(I + I_1)}$