Answers to Selected Homework Problems

1. a. 3.49 rad/s CW
   b. 4180 rad CW
   c. 2.32 rad/s^2 CCW
2. a. 550 rad/s2
   b. 81.7 rad, 13 rev
3. a. 0.105 rad/s CW
   b. 0.419 rad/s CW
   c. 1.68 rad/s^2 CW
4. a. 15.7 ft/s
   b. 0.314 rad/s
   c. 3.14 s
   d. 0.493 rad, 24.7 ft
5. a. The linear speed of the stylus in the goove decreases as it moves toward the center because the radius is less. Each revolution takes the same amount of time but the distance traveled in one revolution is less as the circumference of each groove gets less.
   b. The angular speed of the CD must decrease so that the laser takes more time to traverse the greater and greater circumferences of the rows of pits. If the *angular* speed did not decrease then the *linear* speed would increase at greater radii, instead of remaining constant as required.
6. Ultimately it is friction that can possibly exert a force on the jar and/or the lid in a tangential direction. Normal force can only press toward the center of the jar. However, greater coefficient of friction will result in greater force of friction and greater torque for a given amount of normal force that the person generates by squeezing the jar. A larger diameter gives this frictional force a greater radius, greater lever arm or moment arm and greater torque, so this assists in opening the jar.
7. a. 18 Nm with force perpendicular to wrench
   b. 170 N, 21 cm
8. a. 100 Nm when crank is horizontal
   b. 42 Nm
9. Dividing Nm by rad/s^2 is equivalent to dividing kg m^2/s^2 by $1/s^2$, which equals kg m^2.
10. a. 0.0045 kg m^2
    b. 0.045 kg m^2
    c. Any ring of mass can be thought of a bunch of little masses all the same distance R from the axis. Adding up the products of each mass times R^2 is equivalent to adding up the masses first and then multiplying by R^2.
11. a. $I_J = 39000\, I_E$
    b. $I_M = I_E/40$
12. a. 0.028 Nm CCW
    b. 2.38 Nm CW
    c. 9.51 N
13. a. 5<u>0</u> rad/s^2
    b. 160 rad/s
14. $t = \dfrac{\pi R^2}{\mu_k grT} \quad n = \dfrac{\pi R^2}{2\mu_k grT^2}$
15. 0.45 rad/s^2 CCW
16. a. 26.7 rad/s^2
    b. 0.800 m/s^2
    c. 0.002 N
17. a. 2.0 m/s^2
    b. 5.5 N, 4.7 N
    c. 0.044 Nm
    d. 2.7 m/s^2

18. a. A smaller point means that the radius at which friction can act is very very small and therefore the torque of friction is very very little. In principle if it were *truly a point* of contact there could be no torque regardless of the presence of friction.
    b. Greater rotational inertia means that the top has a greater tendency to maintain its state of motion spinning. This can be achieved by using greater mass (density of material) and/or greater radius.
19. a. 75 J
    b. 2.5 rad/s, 24 kg m^2
    c. 75 J
20. a. 440 kJ
    b. 23 m/s
    c. 44 kW
21. a. 2$\underline{0}$ J
    b. 3.4%
    c. 9.0 m/s
22. a. $h = \dfrac{L^2\omega_0^2}{48g}$
    b. The thrust of the propeller will decrease as it spins slower and the toy will stop rising before the propeller stops spinning. Therefore not all of the original kinetic energy is transformed into gravitational potential energy. Also, some energy is transferred to the air (creating "wind") and transformed into heat.
23. a. 19.6 J, 5.6 kg m^2/s
    b. 0.48 Nm
    c. 5.8 Nms
24. a. 1.3 rad/s
    b. –170 J
25. a. 0.26 rad/s
    b. 0.50 rad/s or 0.10 rad/s (depends on which side of the axis!)
26. a. 28 kg m^2/s, 98 J
    b. 2.1 Hz
    c. 89 J
27. a. $L = m_M\sqrt{Gm_E r}$
    b. 4.5×10^{16} kg m^2/s^2
    c. 21 μs
28. a. -1.77×10^{32} J
    b. 30.3 km/s
    c. 2.66×10^{40} kg m^2/s at each extreme
29. 6110 m/s (nearest Sun), 3680 m/s (farthest)
30. choice from book