1. Cannot be determined with the information given

---

2. x = 8

---

3. either positive or negative

---

4. momentum

---

5. They all have the same speed when they hit the ground.

6. Rock Z

---

7. More than 100 J

---

8. The rubber ball

---

9. $v = \sqrt{2gL\left(1 - \frac{\sqrt{3}}{2}\right)}$

10. 0

11. The same as that of the ball right before the collision

---

12. $\sqrt{2g\mu_k d}$

13. d would stay the same

---

14. $v = \sqrt{\frac{10}{7}gh}$

15. $a_{CoM} = \frac{3}{7}g$

---

16. $a = -\frac{m}{m+M/2}g\,\hat{\mathbf{j}}$

17. $T = \left(1 - \frac{m}{m+M/2}\right)mg$

18. $\tau = -RT\,\hat{\mathbf{k}}$

19. $t = \sqrt{\frac{3h}{g}}$

---

20. $2v$

---

21. The center of the Earth

22. The center of the Earth

---

23. angular velocity

---

24. Not possible because momentum is not conserved

---

25. $\pi/30$ rad/s

---

26. $\frac{-4}{5}\frac{g}{L}$

27. $\frac{1}{5}g$

28. $-\frac{3}{5}g$

29. It would decrease

---

30. $\mathbf{C} = +5\hat{\mathbf{k}}$

---

1) Work done by gravity = +200J

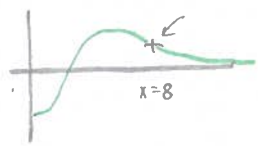
$$W = \vec{F} \cdot \vec{d} = mgd = +200J$$

$$W = -\Delta U = \Delta KE = \tfrac{1}{2}mv_f^2 - \tfrac{1}{2}m(0)^2$$

$\therefore 200J = \tfrac{1}{2}mv_f^2$ → can't determine v if m is not given.

$$V = \frac{2 \times 200J}{m}$$

2) $F = -\dfrac{dU}{dx}$, to find the x where the slope is most negative



3) $W = \vec{F} \cdot \vec{d} = Fd\cos\theta$

θ can be anything so W can be + or −

4) $J = \Delta p$ so impulse must have same dimensions as momentum

5) Since the rocks all have the same total Energy at the start, they will all have the same total Energy at the end. Since the $U = 0$ for all at the end, KE must be the same. thus their speeds must be the same.

$$ME_i = ME_f$$

$$mgh + \tfrac{1}{2}mv_i^2 = 0 + \tfrac{1}{2}mv_f^2$$

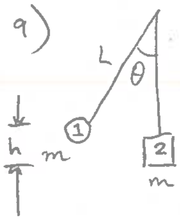
↑ same ↑ same ↑ same for all 3

6) The rock that is thrown down will obviously reach the ground first.

7) Since some energy is lost during the fall due to air resistance, there must be > 100J of potential energy at the beginning.

8) Δp will be largest for the rubber ball $\Delta p = mv_f - mv_i$

9)



$h = L(1-\cos\theta)$ if $\theta = 30°$, then $h = L(1-\frac{\sqrt{3}}{2})$

$U_i = mgh = mgL(1-\frac{\sqrt{3}}{2})$

$\Delta U = \Delta KE \therefore \frac{1}{2}mv^2 = mgL(1-\frac{\sqrt{3}}{2})$

$v = \sqrt{2gL(1-\frac{\sqrt{3}}{2})}$

10) Since the collision is Elastic $KE_i = KE_f \Rightarrow \frac{1}{2}mv_{1i}^2 = \frac{1}{2}mv_{1f}^2 + \frac{1}{2}mv_{2f}^2$

& $P_i = P_f \Rightarrow mv_{1i} = mv_{1f} + mv_{2f}$

(cancel $\frac{1}{2}$'s & m's)

$v_{1i}^2 = v_{1f}^2 + v_{2f}^2$, & $v_{1i} - v_{1f} = v_{2f}$

$v_{1i}^2 - v_{1f}^2 = v_{2f}^2$

$(v_{1i} - v_{1f})(v_{1i} + v_{1f}) = v_{2f}^2$

$(v_{1i} \cancel{- v_{1f}})(v_{1i} + v_{1f}) = (v_{1i} - v_{1f})(v_{1i} \cancel{- v_{1f}})$

$v_{1i} + v_{1f} = v_{1i} - v_{1f}$ } this can only be true if $\underline{v_{1f} = 0}$

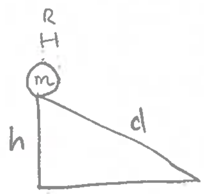
11) Since $v_{1f} = 0$ and $v_{1i} - v_{1f} = v_{2f}$, $\underline{v_{2f} \text{ must } = v_{1i}}$

12) all kinetic energy is transferred to Heat by kinetic friction

$\frac{1}{2}mv^2 = W_{(f)} = \mu_k mg\, d$

$v = \sqrt{2\mu_k g d}$

13) mass doesn't appear in the relation between d and v.
so, d would be the same.

14) 

$u = mgh = mgd\sin\theta$

$KE = \underbrace{\frac{1}{2}I\omega^2}_{\substack{\text{solid sphere} \\ = \frac{2}{5}mR^2}} + \underbrace{\frac{1}{2}mv^2}_{\substack{\text{\& } v = r\omega \\ \omega^2 = \frac{v^2}{R^2}}}$

$mgh = \frac{1}{2}\left(\frac{2}{5}MR^2\frac{v^2}{R^2}\right) + \frac{1}{2}Mv^2$

$= \left(\frac{1}{5} + \frac{1}{2}\right)Mv^2$

$mgh = \frac{7}{10}Mv^2$

$v = \sqrt{\frac{10}{7}gh}$

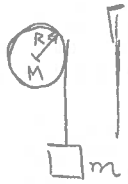
15) $v_f^2 = v_0^2 + 2ad$

$\downarrow$

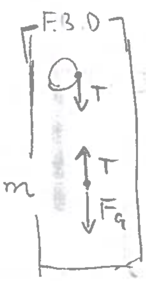
find a $\rightarrow$ $a = \frac{v_f^2}{2d}$

$= \frac{10/7\, gh}{2d} = \frac{10/7\, gd\sin\theta}{2d} = \frac{10/7\, g\, 3/5}{2} = \frac{\cancel{2}}{7}\frac{3}{\cancel{2}}g$

$= \frac{3}{7}g$

16) 

F.B.D



Tension acts on Pully @ $x = R$.

Tension acts on mass m

Gravity acts on mass m

$\tau = -TR = I\alpha$] Torque

$\downarrow$

$I = \frac{1}{2}MR^2$

$\therefore \alpha = \frac{T}{\frac{1}{2}MR} \Rightarrow T = -\frac{1}{2}Ma$

$\alpha = \frac{a}{R}$

Force : $\Sigma F = +T - mg = ma$

$\downarrow$

$-\frac{1}{2}Ma - mg = ma$ (solve for accel a)

$a = -\frac{mg}{m + M/2}\hat{j}$ ($-\hat{j}$ since it is down) [Check: does $a = g$ if $M = 0$?]

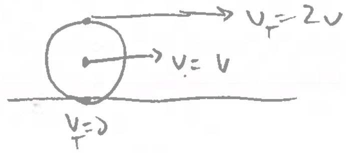
17) $T = ma + mg$ | put in here and solve : $T = \left(1 - \frac{m}{m + M/2}\right)mg$

[check: does $T = mg$ if $M = \infty$?]

18) $\tau = -TR\hat{k}$

19) if $m = M$, then $a = \frac{g}{1 + 1/2} = \frac{2}{3}g$, from kinematics: $h = \frac{1}{2}at^2 \therefore t = \sqrt{\frac{3h}{g}}$

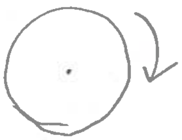
20)



21)

22)

23)



ω is the same everywhere

v_T, a_C, a_T all depend on r

24) Check $p_i = p_f$

$$\underbrace{\begin{array}{r} 2 \times 9 = 18 \\ -\ 0.5 \times 3 = 1.5 \\ \hline 16.5 \end{array}}_{p_i} \qquad \underbrace{\begin{array}{r} 1.5 \times 9 = 13.5 \\ +\ 1.5 \times 3 = 4.5 \\ \hline 18.0 \end{array}}_{p_f}$$

$p_i \neq p_f$ so this collision is not physically possible.

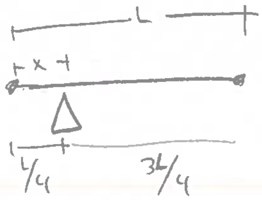
25)

second hand counts seconds

takes 60 seconds to go around once.

$$\omega = \frac{2\pi}{60} = \frac{\pi}{30}\ \frac{rad}{s}$$

26.)



$\tau = mg\frac{L}{4} - mg\frac{3L}{4}$

$I = m\left(\frac{L}{4}\right)^2 + m\left(\frac{3L}{4}\right)^2$

$\tau = I\alpha$

$\alpha = \frac{\tau}{I} = \frac{gL\left(\frac{1}{4} - \frac{3}{4}\right)}{L^2\left(\frac{1}{16} + \frac{9}{16}\right)}$

$= \frac{g}{L}\left(\frac{-2/4}{10/16}\right) = -\frac{g}{L}\left(\frac{2}{4}\frac{16}{10}\right)$

$\underline{\alpha = -\frac{4}{5}\frac{g}{L}}$

27) $\alpha = \frac{4}{5}\frac{g}{L}$

$a = \alpha r = \frac{4}{5}\frac{g}{L} \times \frac{1}{4}L$

$= \frac{1}{5}g$

28) $a = \alpha r$

$a = \frac{4g}{5L} \times \frac{3}{4}L = -\frac{3}{5}g$

29) since $\tau = r \times F = Fr\sin\varphi$, and φ starts at 90,

τ will decrease and so will angular acceleration

30)

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 2 & 0 \\ -2 & 1 & 0 \end{vmatrix} = \hat{i}\underbrace{(2\cdot0 - 0\cdot1)}_{0} + \hat{j}\underbrace{(0\cdot2 - 1\cdot0)}_{0} + \hat{k}\underbrace{(1\cdot1 - 2\cdot-2)}_{+5}$$

$\vec{A} \times \vec{B} = +5\hat{k}$