# 2021/2023 FINAL EXAM

1. At what distance along the central perpendicular axis of a uniformly charged plastic disk of radius 0.650 m is the magnitude of the electric field equal to one third the magnitude of the field at the center of the surface of the disk?

2. An electric field E of 135 N/C points downward in the atmosphere near Earth's surface. We wish to float a sphere weighing 3.6 N in this field by charging the sphere. What charge must be used?

3. The figure above shows four solid spheres, each with charge Q uniformly distributed through its volume…Rank the spheres according to the magnitude of the electric field they produce at point P, smallest first.

4. The figure above shows a section of a long, thin-walled metal tube of radius R = 3.05 cm, with a charge per unit length of $\lambda$ = 19.7 nC/m. What is the magnitude E of the electric field at radial distance r = 2.00R? The electric constant $\epsilon$0= 8.85 × $10^{-12}$

5. You are working on a design of an ink-jet printer. Ink drops of mass m, speed v, and charge q will enter a region of uniform electric field E between two charged plates…Find the expression for the maximum electric field for which drops can still get through without hitting either plate. Neglect the effects of gravity.

6. Two infinitely long wires form the x and y axes of the right-handed coordinate system. A current of 3.00 A flows in the positive x direction. A current of 5.00 A flows in the positive y direction. What is the magnetic field at a point P, located at (3.00 m, 1.00 m)?

7. A certain particle is sent into a uniform magnetic field, with the particle's velocity vector perpendicular to the direction of the field. The figure above gives the period T of the particle's motion versus the inverse of the field magnitude B…What is the ratio m/q of the particle's mass to the magnitude of its charge?

8. The figure above shows an arrangement known as a Helmholtz coil. It consists of two circular coaxial coils, each of 200 turns and radius R = 24.0 cm, separated by a distance s = R…Find the magnitude of the net magnetic field at P, midway between the coils.

9. The current density $\mathcal{J}$ inside a long, solid, cylindrical wire of radius a = 2.8 mm is in the direction of the central axis, and its magnitude varies linearly with radial distance r from the axis according to J = J0r/a, where J0 = 320 A/m2 . Find the magnitude of the magnetic field at r = a/2.

10. The figure above shows a rectangular 40-turn coil of wire, of dimensions 12 cm by 5.0 cm. It carries a current of 80 mA and is hinged along one long side. It is mounted in an

xy plane, at angle θ = 30° to the direction of a uniform magnetic field of magnitude 0.50 T. What is the magnitude of the torque acting on the coil about the hinge line?

11. A circular loop of wire 55 mm in radius carries a current of 120 A. What is the energy density at the center of the loop?

12. The length of a spaceship is measured to be exactly a third of its rest length. To three significant figures, what is the ratio of the spaceship's speed relative to the observer's frame to the speed of light?

13. Suppose that a father is 22.00 y older than his daughter. He wants to travel outward from Earth for 2.000 y and then back for another 2.000 y (both intervals as he measures them) such that he is then 22.00 y younger than his daughter. What constant speed (relative to Earth) is required?

14. Galaxy A is reported to be receding from us with a speed of 0.40c. Galaxy B, located in precisely the opposite direction, is also found to be receding from us at this same speed. What multiple of c gives the recessional speed an observer on Galaxy A would find for Galaxy B?

15. A spaceship, moving away from Earth at a speed of 0.912c, reports back by transmitting at a frequency (measured in the spaceship frame) of 135 MHz. To what frequency must Earth receivers be tuned to receive the report?

16. What must be the momentum of a particle with mass m so that the total energy of the particle is 5.00 times its rest energy?

17. An object that weighs 2.450 N is attached to an ideal massless spring and undergoes simple harmonic oscillations with a period of 0.638 s. What is the spring constant of the spring?

18. A 23 kg object is undergoing lightly damped harmonic oscillations. If the maximum displacement of the object from its equilibrium point drops to 1/4 its original value in 1.6 s, what is the value of the damping constant b?

19. A uniform meter stick is freely pivoted about the 0.35-m mark. If it is allowed to swing in a vertical plane with a small amplitude and friction, what is the frequency of its oscillations?

20. A space craft is in an empty space. It carries on board a gyroscope with a moment of inertia Ig = 22.0 kg · m2 . The moment of inertia of the space craft around the same axis is Isc = 5.15 × 105 kg · m2 …If the orientation of the spacecraft is to be changed by 30.0°, for what time interval should the gyroscope be operated?

21. A solid sphere (radius R, mass M) rolls without slipping down an incline, as shown in the figure above. The linear acceleration of its center of mass is

22. Rank, from smallest to greatest, the magnitudes of the torques about the wrench head in the figure above caused by exerting the same force at the different positions shown.

23. The two rotating systems shown in the figure above differ only in that the two identical movable masses are positioned at different distances from the axis of rotation. If you release the hanging blocks simultaneously from rest, and if the ropes do not slip, which block lands first?

24. A bicycle is traveling south at 4.5 m/s. The mass of the wheel, 2.2 kg, is uniformly distributed along the rim, which has a radius of 20 cm. What are the magnitude and direction of the angular momentum of the wheel about its axle?

25. A 2.0-kg ball with the initial velocity $(5.0\mathbf{i}\hat{i}+ 3.0\mathbf{j}\hat{j})$ m/s collides with a wall and rebounds with the velocity $(-5.0\mathbf{i}\hat{i}+ 3.0\mathbf{j}\hat{j})$ m/s. What is the impulse exerted on the ball by the wall?

26. A disk-shaped space station 185 m in diameter spins uniformly about an axis perpendicular to the plane of the disk through its center. How many rpm (rev/min) must this disk make so that the acceleration of all points on its rim is g/3?

27. An 7.0-kg object moving 4.0 m/s in the positive x direction has a one-dimensional collision with a 2.0-kg object moving 3.0 m/s in the opposite direction. The final velocity of the 7.0-kg object is 2.0 m/s in the positive x direction. What is the total kinetic energy of the two-mass system after the collision?

28. A 0.60-kg object is suspended from the ceiling at the end of a 2.3-m string. When pulled to the side and released, it has a speed of 3.2 m/s at the lowest point of its path. What maximum angle does the string make with the vertical as the object swings up?

29. A champion athlete can produce one horsepower (746 W) for a short period of time. If a 78.0-kg athlete were to bicycle to the summit of a 0.517-km high mountain while expending power at this rate, she would reach the summit in ____ seconds.

30. A 37.0-kg child stands at one end of a 77.0-kg boat that is 4.00 m in length (figure above). The boat is initially 3.00 m from the pier. The child notices a turtle on a rock near the far end of the boat and proceeds to walk to that end to catch the turtle. Neglect friction between the boat and the water. Where is the child relative to the pier when he reaches the far end of the boat?

31. In the figure above, four particles form a square. The particles have charges $q1 = -q2 = 150$ nC and $q3 = -q4 = 200$ nC, and distance a = 5.0 cm. The y component of the net electrostatic force on particle 3 is

1.

$E = \frac{1}{3}E_0$

$R = 0.650\,m$

$E = \left(\frac{\sigma}{2\epsilon_0}\right)\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)$

$\frac{1}{3}E_0 = \left(\frac{\sigma}{2\epsilon_0}\right)\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)$

$\frac{1}{3}\left(\frac{\sigma}{2\epsilon_0}\right) = \left(\frac{\sigma}{2\epsilon_0}\right)\left(1 - \frac{x}{\sqrt{x^2+R^2}}\right)$

$1 - \frac{x}{\sqrt{x^2+R^2}} = \frac{1}{3}$

$-\frac{x}{\sqrt{x^2+R^2}} = -\frac{2}{3}$

$\frac{2}{3} = \frac{x}{\sqrt{x^2+R^2}}$

$\frac{4}{9} = \frac{x^2}{x^2+R^2}$

$\frac{9}{4}x^2 = x^2 + R^2$

$\frac{5}{4}x^2 = R^2$

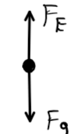
$x = \sqrt{\frac{4}{5}R^2}$

$x = \sqrt{\frac{4}{5}(0.650)^2}$

$x = 0.5813776741\,cm$

$x = 58.1\,m$ $\boxed{C}$

2.




$qE = mg$

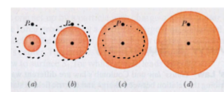
$q = \frac{mg}{E}$

$\frac{3.6}{135}$

$q = 0.02\overline{6}$ (downward.)

$q = -0.027\,C$ $\boxed{E)}$

3.



Volume charge density decreases with an increase of volume and radius.

So, $d < c < b = a$

seperation across object the same, charges balance out.

$\boxed{D)}$

4.

$R = 3.05cm = 0.0305m$

$\lambda = 19.7nC/m = 19.7\times10^{-9}\,C/m$

$r = 2.00R$ $\quad \epsilon_0 = 8.85\times10^{-12}\,\frac{C^2}{Nm^2}$

$E = \frac{\lambda}{2\pi r\epsilon_0}$

$E = \frac{19.7\times10^{-9}}{2\pi(2\cdot0.0305)(8.85\times10^{-12})}$

$E = 5807.821393\,N/C$

$E = 5.81\,kN/C$ $\boxed{A)}$

5.

$F_c = qE, \quad F = ma$

$qE = ma$

$a = \frac{qE}{m}$ (1) $\longrightarrow$ $d = \frac{qE}{m}t^2$

$\frac{d}{2} = \frac{1}{2}at^2$

$t = \sqrt{d\frac{m}{qE}}$

$L = vt$

$L = v\sqrt{d\frac{m}{qE}}$

$\frac{L^2}{v^2} = \frac{dm}{qE}$

$E = \frac{dm}{q}\cdot\frac{v^2}{L^2}$ $\boxed{C}$

6.

$B = \frac{\mu_0 I}{2\pi x}$ $\quad \mu_0 = 4\pi\times10^{-7}$

$I = 3A$

x-direction:

$B = \frac{4\pi\times10^{-7}\cdot3}{2\pi(1)}$

$B = 6\times10^{-7}$

y-direction:

$B = \frac{4\pi\times10^{-7}\cdot5}{2\pi\cdot3}$

$B = 3.3\overline{3}\times10^{-7}$

$P_E = (6\times10^{-7}) - (3.3\overline{3}\times10^{-7})$

$P_E = 2.67\times10^{-7}$ out of the page.

$\boxed{D)}$

## 7.

$B_s = 5T^{-1}$

$T_s = 80ns = 8.0 \times 10^{-9}s$

$$T = \frac{2\pi m}{qB}$$

$$\frac{m}{q} = \frac{TB}{2\pi}$$

$$\frac{m}{q} = \frac{T_s B_s^{-1}}{2\pi}$$

$$\frac{m}{q} = \frac{1}{2\pi}\left(\frac{T_s}{B_s}\right)$$

*Calculating $\frac{T_s}{B_s}$

X-axis: 5 pts. $\longrightarrow \frac{5}{5} = 1T^{-1}$

Y-axis: 4 pts. $\longrightarrow \frac{8 \times 10^{-9}}{4} = 20 \times 10^{-8}s$

$$\frac{T_s}{B_s^{-1}} = \frac{(Y_2 - Y_1)}{(X_2 - X_1)}$$

*Choosing 2 pts on the graph.

$$= \left(\frac{30 \times 10^{-9} - 15 \times 10^{-9}}{2-1}\right)$$

$$\frac{T_s}{B_s^{-1}} = 1.5 \times 10^{-8}$$

$$\frac{T_s}{B_s^{-1}} = 15 \times 10^{-9}$$

$$\frac{m}{q} = \frac{1}{2\pi}\left(15 \times 10^{-9}\right)$$

$$\frac{m}{q} = 2.387324146 \times 10^{-9}$$

$$\frac{m}{q} = 2.3 \times 10^{-9} \quad \boxed{B)}$$

## 8.

$R = 24cm = 0.24m \quad N = 200$

$i = 13.7mA = 0.0137A \quad \mu_0 = 4\pi \times 10^{-7}$

$$B(z) = \frac{\mu_0 i R^2 N}{2(R^2+z^2)^{3/2}}$$

$*z = R/2$

$B_{Net} = B_1 + B_2 = 2B$

$$B_{Net} = 2\left(\frac{\mu_0 i R^2 N}{2\left(R^2+\left(\frac{R}{2}\right)^2\right)^{3/2}}\right)$$

$$= \frac{\mu_0 i R^2 N}{\left(R^2 + \frac{R^2}{4}\right)^{3/2}}$$

$$\longrightarrow \frac{(4\pi \times 10^{-7})(0.0137)(0.24)^2(200)}{\left(0.24^2 + \frac{0.24^2}{4}\right)^{3/2}}$$

$B_{net} = 1.026559593 \times 10^{-5}$

$B_{net} = 10.3 \mu T \quad \boxed{D)}$

## 9.

$a = 2.8mm = 2.8 \times 10^{-3}m \quad r = a/2$

$J = J_0 r/a \quad J_0 = 320A/m^2 \quad \mu_0 = 4\pi \times 10^{-7}$

$$B(r) = \frac{\mu_0 i_{encl}}{2\pi r} = \frac{\mu_0}{2\pi r}\int_0^r J(r) 2\pi r \, dr = \frac{\mu_0}{2\pi}\int_0^r J_0\left(\frac{r}{a}\right)2\pi r \, dr$$

$$B(r) = \frac{\mu_0 J_0 r^2}{3a} \Rightarrow \frac{4\pi \times 10^{-7}(320)\left(\frac{2.8 \times 10^{-3}}{2}\right)^2}{3(2.8 \times 10^{-3})}$$

$B(r) = 9.382890059 \times 10^{-8}$

$B(r) = 94nT \quad \boxed{C)}$

## 10.

$N = 40$

$L = 12cm = 0.12m \quad I = 80mA = 0.8A$

$W = 5cm = 0.05m$

$\theta_1 = 30° \quad B = 0.5T \quad \theta = 90 + 30 = 120°$

$T = NIAB\sin(\theta)$

$= 40(0.8)(0.05 \cdot 0.12)(0.5)\sin(120)$

$T = 0.08313843876 \, N \cdot m$

$T = 8.3 \, mN \cdot m \quad \boxed{A)}$

## 11.

$R = 55mm = 0.055m$

$I = 120A \quad \mu_0 = 4\pi \times 10^{-7}$

$\mu_B = ?$

$$\mu_B = \frac{B^2}{2\mu_0}$$

$$B = \frac{\mu_0 I}{2R}$$

$$= \frac{(4\pi \times 10^{-7})(120)}{2(0.055)}$$

$B = 1.370876794 \times 10^{-3}$

$$\longrightarrow \mu_B = \frac{(1.370876794 \times 10^{-3})^2}{2(4\pi \times 10^{-7})}$$

$\mu_B = 0.7477509787$

$\mu_B = 0.75 \, J/m^3 \quad \boxed{E)}$

## 12.

$L = \frac{1}{3}L_0$

$$L = L_0\sqrt{1 - \frac{v^2}{c^2}}$$

$$\frac{1}{3}L_0 = L_0\sqrt{1 - \frac{v^2}{c^2}}$$

$$\frac{1}{3} = \sqrt{1 - \frac{v^2}{c^2}}$$

$$\frac{1}{9} = 1 - \frac{v^2}{c^2}$$

$$\frac{v^2}{c^2} = \frac{8}{9}$$

$$\longrightarrow v^2 = \frac{8}{9}c^2$$

$$v = \sqrt{\frac{8}{9}c^2}$$

$v = 0.9428090416c$

$v = 0.943c \quad \boxed{B)}$

## 13.

$t_{fi}$ = father initial age $\quad t_{ff}$ = father final age

$t_{di}$ = daughter initial age $\quad t_{df}$ = daughter final age

① $t_{fi}^{*} = t_{di} + 22 \qquad t_{ff}^{*} - t_{fi} = 4$ (total time of travel)

$* \; t_{ff} = t_{df} - 22$

$* \; t_{df} - t_{di} = \gamma(4.00)$ (Lorenz factor)

$* \; t_{ff} - t_{fi} = (t_{df} - 22) - (t_{di} + 22)$

$t_{ff} - t_{fi} = t_{df} - t_{di} - 44$

$* \; 4 = \gamma(4.00) - 44$

$48 = \gamma(4.00)$

$\gamma = 12$

$$\longrightarrow \gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$12 = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$1 = 12\sqrt{1 - \frac{v^2}{c^2}}$$

$$1 = 144\left(1 - \frac{v^2}{c^2}\right)$$

$$\frac{1}{144} = 1 - \frac{v^2}{c^2}$$

$$\longrightarrow \frac{v^2}{c^2} = 1 - \frac{1}{144}$$

$$v = \sqrt{\left(1 - \frac{1}{144}\right)c^2}$$

$v = 0.9965217286c$

$v = 0.9965c \quad \boxed{E)}$

## 14.

$V_A = 0.40c$

$V_B = -0.40c$

$$\frac{v}{c} = \frac{\frac{V_B}{c} - \frac{V_A}{c}}{1 - \frac{V_B V_A}{c}}$$

$$= \frac{-0.40 - (0.40)}{1 - (-0.40 \cdot 0.40)}$$

$\frac{v}{c} = -0.689655517\ldots$

$\frac{v}{c} = 0.69 \quad \boxed{C)}$

## 15.

$\frac{v}{c} = 0.912c$

$f_0 = 135 \, MHz$

$f = ?$

$*\lambda = \frac{c}{f}, \; \lambda_0 = \frac{c}{f_0}$

$$\lambda = \lambda_0\sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

$$\frac{c}{f} = \frac{c}{f_0}\sqrt{\frac{1 + \frac{v}{c}}{1 - \frac{v}{c}}}$$

$$\frac{f}{c} = \frac{f_0}{c}\sqrt{\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}}$$

$$f = f_0\sqrt{\frac{1 - \frac{v}{c}}{1 + \frac{v}{c}}}$$

$$\longrightarrow = 135\sqrt{\frac{1 - 0.912c}{1 + 0.912c}}$$

$f = 28.96217415$

$f = 29.0 \, MHz \quad \boxed{A)}$

## 16.

$p = \gamma m v$

$E_f = 5E_i$

$\gamma mc^2 = 5\gamma mc^2$

$\gamma = 5$

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$5 = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\frac{1}{5} = \sqrt{1 - \frac{v^2}{c^2}}$$

$$\frac{1}{25} = 1 - \frac{v^2}{c^2}$$

$$v = \sqrt{1 - \frac{1}{25}c^2}$$

$v = 0.9797958971$

$\longrightarrow p = \gamma m v$

$p = 5m(0.9797958971)$

$p = 4.898979486 \, mc$

$p = 4.90 \, mc \quad \boxed{D)}$

17.

$m = 2.450N$

$T = 0.638s$

$k = ?$

$F_g = mg$

$2.450 = m(9.8)$

$m = 0.25$

$T = 2\pi\sqrt{\frac{m}{k}}$

$\left(\frac{T}{2\pi}\right)^2 = \frac{m}{k}$

$k = \frac{m}{\frac{T^2}{4\pi^2}}$

$k = \frac{0.25}{0.638^2/4\pi^2}$

$k = 24.24702096$

$k = 24.2\ N/m$ $\boxed{B)}$

18.

$m = 23kg$ $t = 1.6s$

$A = \frac{1}{4}A_0$

$A = A_0 e^{-\alpha t}$

$\frac{1}{4}A_0 = A_0 e^{-\alpha t}$

$\frac{1}{4} = e^{-\alpha t}$

$\ln\left(\frac{1}{4}\right) = -\alpha t$

$\alpha = -\frac{\ln(\frac{1}{4})}{t}$

$\alpha = -\frac{\ln(\frac{1}{4})}{1.6}$

$\alpha = 0.8664339757$

$\alpha = \frac{b}{2m}$

$b = \alpha 2m$

$b = 0.8664339757 \cdot 2(23)$

$b = 39.85596288$

$b = 39.6\ \frac{kg}{s}$ $\boxed{E)}$

19.

$d = 0.35L$

Using the Parallel axis theorem:

$L_{eq} = \frac{I}{md}$

$I = I_{cm} + md^2$

$*d = dL$

$I = \frac{mL^2}{12} + md^2$

$I = \frac{mL^2}{12} + m\left[(0.5 - 0.35)L\right]^2$

$I = mL^2\left(\frac{1}{12} + \frac{9}{400}\right)$

$I = \frac{127}{1200}ML^2$

$L_{eq} = \frac{\frac{127}{1200}ML^2}{m \cdot (0.5-0.35)L}$

$L_{eq} = \frac{127}{180}L$

$L_{eq} = \frac{127}{180}(1)$

$L_{eq} = \frac{127}{180}$

$T = 2\pi\sqrt{\frac{L_{eq}}{g}}$

$\frac{1}{f} = 2\pi\sqrt{\frac{L_{eq}}{g}}$

$f = \frac{1}{2\pi\sqrt{\frac{L_{eq}}{g}}}$

$f = \frac{1}{2\pi\sqrt{\frac{127/180}{9.8}}}$

$f = 0.593154134\ Hz$

$f = 0.59\ Hz$ $\boxed{C)}$

20.

$I_g = 22.0 kg\cdot m^2$

$I_{sc} = 5.15\times10^5 \cdot kg\cdot m^2$

$\omega_g = 1.00\times10^2\ rad/s$

$\theta = 30°$

$t = ?$

$*L_{sc} = I_{sc}\omega*$

$\omega = \frac{\theta}{t}$

$*L_g = I_g\omega_g$

$*\theta \longrightarrow rad$

$\theta = 30° \cdot \frac{\pi}{180}$

$\theta = \frac{\pi}{6} rad.$

$*$

$L_g + L_{sc} = 0$

$L_{sc} = -L_g$

$*I_{sc}\omega = -I_g\omega_g$

$5.5\times10^5\left(\frac{\theta}{t}\right) = (-22)(-1.00\times10^2)$

$\frac{\theta}{t} = \frac{(-22)(-1.00\times10^2)}{5.5\times10^5}$

$t = \theta \div \frac{(-22)(-1.00\times10^2)}{5.5\times10^5}$

$t = \overset{*}{\frac{\pi}{6}} \div \frac{(-22)(-1.00\times10^2)}{5.5\times10^5}$

$t = 122.5697134\ s$

$t = 123\ s$ $\boxed{D)}$

21.

$a = \frac{mg\sin\theta}{(m+I)/R^2}$

$I_{sphere} = \frac{2}{5}MR^2$

$= \frac{mg\sin\theta}{(m+\frac{2}{5}mR^2)/R^2}$

$= \frac{mg\sin\theta}{m(1+\frac{2}{5}R^2)/R^2}$

$= \frac{g\sin\theta}{1+\frac{2}{5}}$

$= \frac{g\sin\theta}{7/5}$

$a = \frac{5}{7}g\sin\theta$ $\boxed{D)}$

22.

Sample Calculations:

Let $F = 9N$, and $r = 2, 6, 8$ depending on Position.

a) $\theta \approx 225°, r = 2$

$\tau = |rF\sin\theta|$

$= |2(9)\sin 225°|$

$\tau = 12.728$

b) $\theta \approx 315°, r = 6$

$\tau = |rF\sin\theta|$

$= |6(9)\sin 315°|$

$\tau = 38.184$

c) $\theta \approx 90°, r = 6$

$\tau = |rF\sin\theta|$

$= |6(9)\sin 90°|$

$\tau = 54$

d) $\theta \approx 270°, r = 6$

$\tau = |rF\sin\theta|$

$= |6(9)\sin 90°|$

$\tau = 54$

e) $\theta \approx 270°, r = 2$

$\tau = |rF\sin\theta|$

$= |2(9)\sin 270°|$

$\tau = 18$

f) $\theta \approx 270°, r = 8$

$\tau = |rF\sin\theta|$

$= |8(9)\sin 270°|$

$\tau = 72$

$a < e < b < c = d < f$ $\boxed{E)}$

23.

The block on the right will land first.

The block positioned farther from the axis of rotation has a larger initial tangential velocity, due to the conservation of angular momentum. (The two points on the right is closer to the wheel, so it lands first.)

$\boxed{A)}$

24.

$V = 4.5 m/s\ [S]$

$m = 2.2kg$

$r = 20cm = 0.2m$

$L = I\omega$

"thin-walled hollow cylinder."

$I_{Rim} = mR^2$

$= 2.2(0.2)^2$

$I_{Rim} = 0.088$

$V = r\omega$

$\omega = \frac{V}{r}$

$= \frac{4.5}{0.2}$

$\omega = 22.5$

$L = 0.088(22.5)$

$L = 1.98\ kg\cdot ms^2$

Since the wheel is moving south, the angular momentum vector would point east, as the direction of angular momentum is perpendicular to both the radius and direction vector.

$L = 2.00\ kg\cdot ms^2$ towards the east.

$\boxed{D)}$

25.

$m = 2kg$

$V_i = (5\hat{i} + 3\hat{j})m/s$

$V_f = (-5\hat{i} + 3\hat{j})m/s$

$\Delta p = p_2 - p_1$

$= mv_f - mv_i$

$= 2(-5\hat{i} + 3\hat{j}) - 2(5\hat{i} + 3\hat{j})$

$= -10\hat{i} + 6\hat{j} - 10\hat{i} - 6\hat{j}$

$\Delta p = -20\hat{i}\ N/s$ $\boxed{D)}$

26.

$d = 185m$ $(r = 92.5m)$

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

$a = \frac{V^2}{r}$

$\frac{9}{3} = \frac{V^2}{92.5}$

$V = \sqrt{\frac{9.8}{3} \cdot 92.5}$

$V = 17.38294183\ m/s$

$rpm = \frac{V}{2\pi r} \cdot 60$

$= \frac{17.38294183}{2\pi(92.5)} \cdot 60$

$rpm = 1.794539103$

$rpm = 1.79$ $\boxed{B)}$

27.

$m_1 = 7kg$

$V_{1i} = 4m/s\ [x]$, $V_{2f} = 2m/s\ [x]$

$m_2 = 2kg$

$V_{2i} = -3m/s\ [x]$

$E_{kf} = ?$

Using conservation of momentum:

$p_i = p_f$

$m_1V_{1i} + m_2V_{2i} = m_1V_{1f} + m_2V_{2f}$

$7(4)+2(-3) = 7(2)+2(V_{2f})$

$\frac{28-6-14}{2} = V_{2f}$

$V_{2f} = 4m/s$

Now, conservation of momentum:

$E_{ki} = E_{kf}$

Looking for energy after collision, so solve for $E_{kf}$.

$E_{kf} = \frac{1}{2}m_1V_{1f}^2 + \frac{1}{2}m_2V_{2f}^2$

$E_{kf} = \frac{1}{2}(7)(2)^2 + \frac{1}{2}(2)(4)^2$

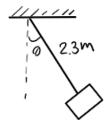
$E_{kf} = 30J$ $\boxed{C}$

28.

$m = 0.60kg$

$d = 2.3m$

$V_i = 3.2m/s$




Using Kinetic Energy

$E_K = \frac{1}{2}mv^2$

$= \frac{1}{2}(0.6)(3.2)^2$

$E_K = 3.072J$

Now using gravitational potential energy:

$E_K = mgh$

$h = \frac{E_K}{mg}$

$= \frac{3.072}{0.6(9.8)}$

$h = 0.5224489$

to find theta, compute difference in height.

$h_f = h_i - h$

$= 2.3 - 0.522489$

$h_f = 1.77755$

$\theta = \cos^{-1}\left(\frac{h_f}{h_i}\right)$

$= \cos^{-1}\left(\frac{1.77755}{2.3}\right)$

$\theta = 39.38968$

$\theta = 39°$ $\boxed{E}$

29.

$P = 746W$

$m = 78kg$ $h = 0.517km = 517m$

First, Work

$W = mgh$

$= 78(9.8)(517)$

$W = 395194.8J$

Next, using Power:

$P = \frac{\Delta E}{\Delta t}$ $*\Delta E = W$

$P = \frac{W}{\Delta t}$

$\Delta t = \frac{W}{P}$

$= \frac{395194.8}{746}$

$\Delta t = 529.7517426s$

$\Delta t = 530s$ $\boxed{A}$

30.

$m_c = 37kg$

$m_b = 77kg$

$x_b = 4m$

$x_p = 3m$

$x_t = x_b + x_p = 7m$

$d = \frac{m_c + x_p + m_b + x_t}{m_c + m_b}$

$= \frac{(37)(3)+(77)(7)}{37+77}$

$d = 5.70154m$

$d = 5.70m$ $\boxed{D}$

31.

$q_1 = -q_2 = 150nC = 150\times10^{-9}C$

$q_3 = -q_4 = 200nC = 200\times10^{-9}C$

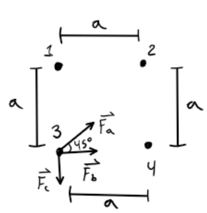
$a = 5cm = 0.05m$

First, finding the product of the charges:

$k = q_1 \cdot q_2 \cdot q_3 \cdot q_4$

$= (150)(-150)(200)(-200)$

$k = 9.0\times10^8$




Finding the sum of forces on 3 to find its y-component:

$F_{nety} = F_a\sin45° + \underset{0}{\underset{\downarrow}{F_b}} - F_c$

$= \frac{k(q_bq_a)\sin45°}{(a\sqrt{2})\cdot2} - k\frac{q_bq_a}{a^2}$

$= k\frac{q_bq_a}{a^2}\left(\frac{\sin45°}{2} - 1\right)$

$F_{nety} = 9\times10^8 \cdot \left(\frac{200\times10^{-9} \cdot 150\times10^{-9}}{(0.05)^2}\right)\left(\frac{\sin45°}{2} - 1\right)$

$= \left(\frac{27}{2500}\right)\left(\frac{-4+\sqrt{2}}{4}\right)$

$F_{nety} = -0.006981623382N$

$F_{nety} = -0.07N$ $\boxed{B}$

QUESTION 31:
Final answer is one decimal place off, likely due to wrong exponent. Answer is right though!