2022 FINAL EXAM

1. A motorcycle is following a car that is traveling at constant speed on a straight highway… How far does the motorcycle travel from the moment it starts to accelerate (at time t1) until it catches up with the car (at time t2)?

2. A canoe has a velocity of 0.420 m/s southeast relative to the earth. The canoe is on a river that is flowing at 0.710 m/s east relative to the earth. Find the direction of the velocity of the canoe relative to the river.

3. A window washer of m = 75.0 kg is sitting on a platform suspended by a system of cables and pulleys as shown above…Find the magnitude of the minimum force F that allows the window washer to move upward.

4. A circular hoop of mass m, radius r, and infinitesimal thickness rolls without slipping down a ramp inclined at an angle θ with the horizontal…What is the maximum angle θ the hoop could ride down without worrying about skidding?

5. Four charged particles are placed at the corners of a square. Particles 1, 2, and 4 all carry an identical positive charge qq. For the net force exerted on particle 1 to be zero, what charge must be given to particle 3, which is in the corner diametrically opposite particle 1?

6. In a uniform charge distribution shown in the figure above, each of the three arcs forms one-fourth of the circumference of a ring. The upper right and lower left arcs each carry a positive charge q, while the upper left arc carries a charge −q. Determine the magnitude of the electric field at P.

7. The two-cavity metal object in the figure above is electrically neutral, but each cavity contains a charged particle as shown. What is the charge on the outer surface of the object?

8. A small sphere with mass 4.00 mg and charge 50.0 nC hangs from a thread near a very large, charged insulating sheet. The charge density on the sheet’s surface is uniform and equal to −3.50 nC/m2. Find the angle of the thread, θ.

9. Consider a pattern of five electric field lines shown in the figure above. Rank positions A, B, and C according to the magnitude of their electric fields, from greatest to smallest.

10. An electron (charge −1.60 × 10−19 C) moves at 2.10 × 105 m/s through a uniform 1.65 T magnetic field that points in the +y-direction. The velocity of the electron lies in the xy-plane and is directed at 40° to the +x-axis and 50° to the +y-axis. The magnetic force on the electron is

11. A vertical straight wire 40.0 cm in length carries a current. You do not know the current's magnitude or whether the current is moving upward or downward…Find the magnitude of the current and its direction.

12. Electrons are made to flow through the copper strip of the figure above…If the number of mobile electrons per unit volume in copper is 8.46 × 1028 m−3 and the current in the strip is 12.0 A, calculate the potential difference across the width of the strip when conditions have been allowed to equilibrate.

13. A wire is coiled in the shape of a helical spring with closely spaced turns. When current is passed through it, the coil tends to

14. A coil with magnetic moment 1.45 A · m2 is oriented initially with its magnetic moment antiparallel to a uniform 0.865 T magnetic field. What is the change in potential energy of the coil when it is rotated 180° so that its magnetic moment is parallel to the field?

15. A proton moves at 6.67 × 105 m/s undeflected in the +x direction through a velocity selector, a device containing crossed electric and magnetic fields. You measure the electric field to be 2.0 × 105 N/C in the positive z direction. What are the magnitude and direction of the magnetic field?

16. Four very long, current-carrying wires in the same plane intersect to form a square with side lengths 47.0 cm. The currents running through the wires are 8.0 A, 20.0 A, 11.0 A, and I. Find the magnitude of the current I that will make the magnetic field at the center of the square equal to zero and the direction of the current I.

17. An alpha particle (charge +2e) and an electron move in opposite directions from the same point, each with the speed of 2.50 × 105 m/s (see the figure above). Find the magnitude and direction of the total magnetic field these charges produce at point P, which is 8.45 nm from each charge.

18. Two long, parallel wires are separated by a distance of 2.40 cm. The force per unit length that each wire exerts on the other is 4.00 × 10−5 N/m, and the wires repel each other. The current in one wire is 0.600 A. What is the current in the second wire?

19. A long straight very thin wire on the y-axis carries a 10-A current in the positive y-direction. A circular loop 0.50 m in radius, also of very thin wire and lying in the yz-plane, carries a 9.0-A current, as shown. Point P is on the positive x-axis, at a distance of 0.50 m from the center of the loop. What is the magnetic field vector at point P due to these two currents?

20. A proton has total energy that is 5.000 times its rest energy. What is the proton speed as a fraction of the speed of light?

21. Jane flies in her spacecraft at 0.600c relative to the planet Arrakis. As she passes Paul, at rest on Arrakis, they both start timers. According to Jane's timer, 26.0 s elapses from when Paul starts his timer to when he stops his timer. What does Paul's timer read when he stops it?

22. An enemy spaceship is moving toward your starfighter with a speed of 0.400c, as measured in your reference frame…iIf you measure the enemy ship to be 7.00 × 106 km away from you when the missile is fired, how much time, measured in your frame, will it take for the missile to reach you?

23. A simple pendulum consists of a 1.00-kg bob on a string 1.00 m long…Determine the numerical value of the damping coefficient b.

24. A rock of mass m is attached to the left end of a uniform meter stick of mass 2m. How far from the left end of the stick should the triangular object be placed so that the combination of the meter stick and rock is in balance?

25. What is the moment of inertia about the x axis of the rigid object in the figure above? (Treat the balls as particles.)

26. 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?

27. 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?

28. A 60.0-kg person rides in an elevator while standing on a scale. The scale reads 400 N. The acceleration of the elevator is closest to

29. A uniform solid sphere of mass M and radius R rotates with an angular speed ω about an axis through its center…What must be the angular speed of the cylinder so it will have the same rotational kinetic energy as the sphere?

30. During a collision with a wall, the velocity of a 0.200-kg ball changes from 20.0 m/s toward the wall to 12.0 m/s away from the wall. If the time the ball was in contact with the wall was 60.0 ms, what was the magnitude of the average force applied to the ball?

31. A 7.0-kg rock is subject to a variable force given by the equation…If the rock initially is at rest at the origin, find its speed when it has moved 9.0 m.

1.

$V_{1i} = 20.5$ m/s (V_{car}) $d_i = 50$m (x_i)

$V_{2i} = 20.5$ m/s ($V_{motorcycle}$)

$t_1 = 2.15$ m/s $a = 4.12$ m/s^2 $t_2 = ?$

$t_2 - t_1 = ?$

Step 1: Position

$X_{car} = X_i + V_{car} t$

$X_{car} = 50 + 20.5t$

Step 2: Position as a f'n of time:

$X_{motorcycle} = V_{motorcycle} \cdot t + \left[\frac{1}{2}a(t_2-t_1)^2\right]$

$X_{motorcycle} = 20.5t + \left[\frac{1}{2}(4.12)(t_2-t_1)^2\right]$

NOTE: Car and motorcycle have the same position, So:

$X_{car} = X_{motorcycle}$

$t_2 - t_1 = \sqrt{\frac{2(X_{car} - 20.5t)}{4.12}}$

$t_2 - t_1 = \sqrt{\frac{2(50 + 20.5t - 20.5t)}{4.12}}$

$t_2 - t_1 = 4.926646391$ s

$t_2 - t_1 = 4.93$ s

Step 3: Equation relating initial velocity, final distance, acceleration and time:

$x_f = V_i(t_2-t_1) + \frac{1}{2}a(t_2-t_1)^2$

$x_f = 20.5(4.93) + \frac{1}{2}(4.12)(4.93)^2$

$x_f = 151.133094$m

$x_f = 151$m $\boxed{C)}$

2. Relative Velocity

$V_{ce} = 0.420$ m/s Southeast

(canoe w.r.t earth)

$V_{re} = 0.710$ m/s east

Step 1: Components:

$\vec{V}_{cex} = V_{ce}\cos(-45°)$

$= 0.420\cos(-45°)$

$\vec{V}_{cex} = 0.2969848481$ m/s

$\vec{V}_{cey} = V_{ce}\sin(-45°)$

$= 0.420\sin(-45°)$

$\vec{V}_{cey} = -0.2969848481$ m/s

$\vec{V}_{rex} = 0.710$ m/s

$\vec{V}_{rey} = 0$

Step 2: Relative velocity

$\vec{V}_{xy} = \vec{V}_x - \vec{V}_y$

$\vec{V}_x = \vec{V}_{cex} - \vec{V}_{rex}$

$= 0.2969848481 - 0.710$

$\vec{V}_x = -0.4130151519$

$\vec{V}_y = \vec{V}_{cey} - \vec{V}_{rey}$

$= -0.2969848481 - 0$

$\vec{V}_y = -0.2969848481$ m/s

Step 3: Angle

$\emptyset = \tan^{-1}\left(\frac{\vec{V}_y}{\vec{V}_x}\right)$

$\emptyset = \tan^{-1}\left(\frac{-0.2969848481}{-0.4130151519}\right)$ $\frac{y}{x}$ = South of west

$\emptyset = 35.71859939$

$\emptyset = 35.7$ South of West. $\boxed{B)}$

3.

$m = 75$ kg

Using Newton's Second Law:

$\sum F_{Net} = F_N + F_T$

$\sum F_{Net} = F_N + 2F_N$

$\sum F_{NET} = 3F_N$

$F = mg$

$3F_N = mg$

$F_N = \frac{mg}{3}$

$F_N = \frac{75 \cdot 9.8}{3}$

$F_{min} = 245$ N $\boxed{E)}$

$*F_T = 2F_N$

(rope is supporting the platform with 2F force from the first pulley.)

4.

$\mu_s = 0.852$

Step 1: Acceleration

$I_{hoop} = mr^2$

$F = ma = mg\sin\theta - F_f$

$F_f = \mu mg\cos\theta$

Step 2: Rotational Motion

$\tau = I\alpha = F_f r$

$mr^2\alpha = \mu mg\cos\theta r = F_f r$

$m\alpha = \mu mg\cos\theta = F_f$

So,

$ma = mg\sin\theta - F_f$

$ma = mg\sin\theta - ma$

$2ma = mg\sin\theta$

$a = \frac{1}{2}g\sin\theta$

Step 3: Minimum coefficient of friction

$r\alpha = \mu g\cos\theta$

$a = r\alpha = \mu g\cos\theta$

$\mu_{min} = \frac{a}{g\cos\theta}$

$\mu_{min} = \frac{1}{2}g\sin\theta \cdot \frac{1}{g\cos\theta}$

$\mu_{min} = \frac{1}{2}\tan\theta$

Step 4: Angle

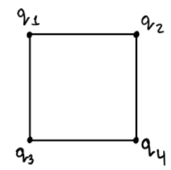
$\emptyset = \tan^{-1}(2\mu_{min})$

$\emptyset = \tan^{-1}(2 \cdot 0.852)$

$\emptyset = 59.59326822$

$\emptyset = 59.6°$ $\boxed{D)}$

5.)



$q_1 = q_2 = q_4$

Charge on q_3 must be −ve.

Step 1: Resultant force of 2 and 4.

$F = \sqrt{F_2^2 + F_4^2}$

$F_2 = F_4 = \frac{kq^2}{d^2}$ $\quad F_3 = \frac{kqq_3}{(\sqrt{2}d)^2} = \frac{kqq_3}{2d^2}$

For F_1 to be 0:

$F = F_3$

$\sqrt{2\left(\frac{kq^2}{d^2}\right)^2} = \frac{kqq_3}{2d^2}$

$\sqrt{2}\,\frac{kq^2}{d^2} = \frac{kqq_3}{2d^2}$

$q_3 = 2\sqrt{2}q$ $\quad$ * q_3 −ve, so:

$q_3 = -2\sqrt{2}q$ $\boxed{D)}$

6.

Step 1: x-component of electric field:

*Let σ = linear charge density

*Let $Rd\theta$ be the length of a very small part.

$$E_x = \int_0^{\pi/2} \frac{k\sigma R}{R^2}\cos\theta d\theta$$

$$= \frac{k\sigma}{R} = \frac{k}{R}\cdot\frac{2q}{\pi R} = \frac{2kq}{\pi R}$$

Step 2: y-component

$E_y = \frac{2kq}{\pi R^2}$

Step 3: E_{Net}

$E_{Net} = \sqrt{E_x^2 + E_y^2}$

$= \sqrt{2\left(\frac{2kq}{\pi R^2}\right)^2}$

$E_{NET} = \sqrt{2}\left(\frac{2kq}{\pi R^2}\right)$ $\boxed{B)}$

7. Using induced charges properties:

$q_1 = +q$, $q_2 = -2q$

$q_{Net} = q_{induced_1} + q_{induced_2}$

$q_{Net} = q - 2q$

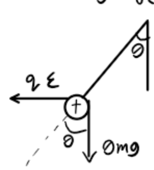
$q_{Net} = -q$ $\boxed{A)}$

8.)

$m = 4mg = 4\times10^{-6}$ kg

$q = 50nC = 50\times10^{-9}C$

T = charge density = $3.50 nC/m^2 = 3.50\times10^{-9}$



$\tan\theta = \frac{q\mathcal{E}}{mg}$

$\theta = \tan^{-1}\left(\frac{q\mathcal{E}}{mg}\right)$ $\quad$ * $\mathcal{E}$ = electric field = $T/2\mathcal{E}_0$

* $\mathcal{E}_0 = 8.85\times10^{-12}\, C^2/N\cdot m^2$

$\theta = \tan^{-1}\left(\frac{qT}{2\mathcal{E}_0 mg}\right)$

$\theta = \tan^{-1}\left(\frac{50\times10^{-9}\times3.50\times10^{-9}}{2\times8.85\times10^{-12}\cdot4\times10^{-6}\times9.8}\right)$

$\theta = 14.15587005$

$\theta = 14.2$ $\boxed{C)}$

9.

The closer the field lines, the stronger the electric field.

So, by observation:

$B > A > C$ $\boxed{B)}$

10.

$q = -1.60\times10^{-19}C$

$v = 2.10\times10^5 m/s$

$B = 1.65T$

$\theta = 50°$

$F = qvB\sin\theta$

$F = -1.60\times10^{-19}\cdot2.10\times10^5\cdot1.65\sin50°$

$F = -4.246950393\times10^{-14}N$

$F = (-4.25\times10^{-24})N$ $\boxed{C)}$

11.

$L = 40cm = 0.4m$
$B = 0.0350T$
$F = 0.0120N \quad \emptyset = 90^\circ$ (North)

$F = BIL\sin\theta$

$I = \frac{F}{BL\sin\theta}$

$I = \frac{0.0120}{0.035 \cdot 0.4 \sin 90^\circ}$

$I = 0.857142A$

$I = 0.857A$

Using the right hand rule, the current travels verticallr upward, so: $\boxed{E)}$

12.

$B = 2.00T$
$I = 12A$
$L = 1mm = 0.001m$
$n = 8.46 \times 10^{28} m^{-3}$
$q = 1.6 \times 10^{-19}$

Potential difference:

$V_p = \frac{IB}{nqL}$

$V_p = \frac{12 \cdot 2}{8.46 \times 10^{28} \cdot 1.6 \times 10^{-19} \cdot 0.001}$

$V_p = 0.000001773$

$V_p = 1.77 \mu V \; \boxed{A)}$

13.

When passing current, the spring will form north and south poles on either side of the spring. Because they're opposite, both sides will attract eachother, causing the spring to shorten. $\boxed{B)}$

14.

$\mu = 1.45 A \cdot m^2 \quad \emptyset_i = 180^\circ$
$B = 0.865T \quad \emptyset_f = 360^\circ$

$U = -\mu B\cos\theta$

$U_i = -1.45(0.865)(\cos 180^\circ \qquad U_f = -1.45(0.865)(\cos 360^\circ$

$U_i = 1.25425 \qquad U_f = -1.25425$

$\Delta U = U_f - U_i$

$\Delta U = -1.25425 - 1.25425$

$\Delta U = -2.5085$

$\Delta U = -2.51 \; \boxed{D)}$

15.

$\vec{V} = 6.67 \times 10^5 m/s \longrightarrow +x$
$\vec{E} = 2.0 \times 10^5 N/C \longrightarrow z$

$\vec{E} = \vec{V} \times \vec{B}$

$\vec{B} = \frac{\vec{E}}{\vec{V}}$

$= \frac{2.0 \times 10^5}{6.67 \times 10^5}$

$\vec{B} = 0.29985 0075$

$\vec{B} = 0.30T$

$\boxed{E)}$

Using the right hand rule, the direction must move in the negative y direction to balance the forces.

16. $*\mu_0 = 4\pi \times 10^{-7}$

$L = 47cm = 0.47m \quad (R = 0.235)$

$I_1 = 11A, I_2 = 8A, I_3 = 20A$

$$B = \frac{\mu_0 I}{2\pi L}$$

We know:

$$B_1 + B_2 + B_3 + B_4 = 0$$

$$\frac{\mu_0 I_1}{2\pi L} + \frac{\mu_0 I_2}{2\pi L} + \frac{\mu_0 I_3}{2\pi L} + \frac{\mu_0 I_4}{2\pi L} = 0$$

$$\frac{\mu_0}{2\pi L}(I_1 + I_2 + I_3 + I_4) = 0$$

$$I_1 + I_2 + I_3 + I_4 = 0$$

$$I_4 = -(I_1 + I_2 + I_3)$$

$$I_4 = -(11 + 8 - 20)$$

$$I_4 = 1A$$

Using the right hand rule, the current travels downwards, so:

$\boxed{B)}$

17.

$V = 2.5 \times 10^5 m/s$

$\theta = 140°\quad \theta_2 = 40°$ (between electron and axis)

$q_p = 2 \cdot 1.6 \times 10^{-19}$ $\quad \mu_0 = 4\pi \times 10^{-7}$

$q_e = -1.6 \times 10^{-19}$

$r = 8.45nm = 0.00845m$

$$\vec{B} = \frac{\mu_0}{4\pi} q \cdot \frac{\vec{v} \times \hat{r}}{r^2}$$

$$* \frac{v \times r}{r^2} = \frac{v \sin\theta}{r^2}$$

$$B = B_{a1} + B_{encl}$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{q_p \cdot v \sin\theta_1}{r^2} + \frac{\mu_0}{4\pi} \cdot \frac{q_e \cdot v \sin\theta_2}{r^2} \quad * q_p = 2q_e$$

$$= \frac{\mu_0}{4\pi} \cdot \frac{q_e v}{r^2} \left[2\sin\theta + \sin\theta_2\right]$$

$$= \frac{4\pi \times 10^{-7}}{4\pi} \cdot \frac{1.6 \times 10^{-19} \cdot 2.5 \times 10^5}{(8.45 \times 10^{-9})^2} \left[2\sin 140 + \sin 40\right]$$

$$B = 1.080277486 \times 10^{-3}$$

$$B = 0.108mT$$

And using the right hand rule, $q(\vec{v} \times \vec{r})$ will be in the $+z$ direction, out of the page.

$\boxed{C)}$

18.

$L = 2.40\text{cm} = 0.0240\text{m}$

$\frac{F}{l} = 4.00\times10^{-5}\ \text{N/m}$

$I_1 = 0.600\text{A}$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\cdot\frac{I_1 I_2}{L}$$

$$I_2 = \frac{F}{l}\cdot\frac{2\pi}{\mu_0}L\cdot\frac{1}{I_1}$$

$$I_2 = 4\times10^{-5}\cdot\frac{2\pi}{4\pi\times10^{-7}}\cdot0.0240\cdot\frac{1}{0.600}$$

$$I_2 = 8\text{A} \quad \boxed{A)}$$

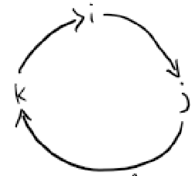
19.

$I_1 = 10\text{A}$

$R = 0.5\text{m}$ $\quad \mu_0 = 4\pi\times10^{-7}$

$I_2 = 9\text{A}$

$d = 0.5\text{m}$



$\hat{i}\times\hat{j} = \hat{k}$

$\hat{j}\times\hat{k} = \hat{i}$

$\hat{k}\times\hat{i} = \hat{j}$

$\hat{j}\times\hat{i} = -\hat{k}$

$\hat{k}\times\hat{j} = -\hat{i}$

$\hat{i}\times\hat{k} = -\hat{j}$

$$B_{req} = B_{wire} + B_{loop}$$

$$= \frac{\mu_0 I_1}{2\pi R} + \frac{\mu_0 I d^2}{2(d^2+R^2)^{3/2}}$$

$$= \frac{4\pi\times10^{-7}(10)}{2\pi(0.5)}\overset{\hat{j}\times\hat{i}}{(-k)} + \frac{4\pi\times10^{-7}(9)(0.5)^2}{2(0.5^2+0.5^2)^{3/2}}(-i) \rightarrow \hat{k}\times\hat{j}$$

$$B_{req} = 4\times10^{-6}\,\text{T}(-k) + 3.998594644\times10^{-6}\,\text{T}(-i)$$

$$B_{req} = 4.00\mu\text{T}(-k) + 4\mu\text{T}(-i)$$

$$B_{req} = -4\mu\text{T}(k) - 4\mu\text{T}(i) \quad \boxed{D)}$$

20.

$m_{proton} = 1.67\times10^{-27}\,\text{kg}$

$c = 3\times10^{8}\,\text{m/s}, \quad E = mc^2$

Total energy of a moving proton:

$$E_{(T)} = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}}$$

We know: $E_{(T)} = \dfrac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} = 5E_{(T)}$

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

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

$$1 = 25\cdot\left(1-\frac{v^2}{c^2}\right)$$

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

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

$$\frac{v}{c} = 0.9797958971$$

$$\frac{v}{c} = 0.9798 \quad \boxed{B)}$$

21.

$v = 0.600c \quad t' = 26\text{s}$

Time observed given by:

$$t' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$t = t'\sqrt{1-\frac{v^2}{c^2}}$$

$$= 26\sqrt{1-(0.600)^2}$$

$$t = 20.8\text{s} \quad \boxed{D)}$$

22.

$u = 0.400c$

$v' = 0.700c$ $\quad c = 3\times10^8 \text{ m/s}$

$d = 7.00\times10^6 \text{ km}$

$$v = \frac{v' + u}{1 + u\frac{v'}{c^2}}$$

$$v = \frac{0.700c + 0.400c}{1 + 0.400c \cdot \frac{0.700c}{c^2}}$$

$$v = 0.859375c$$

$$t = \frac{d}{v'}$$

$7\times10^6 \text{ km} = 7\times10^9 \text{ m}$

$$t = \frac{7.00\times10^9}{0.859375(3\times10^8)}$$

$$t = 27.15 \text{ s}$$

$$t = 27.2 \text{ s} \quad \boxed{C)}$$

23.

$m = 1\text{kg}$ $\quad L = 1\text{m}$

$\Delta t = 25.6\text{ s}$ $\quad \theta_i = 6°$

$\theta_f = 5.40°$

$$\theta(t) = \theta_0 e^{\frac{-bt}{2m}} \longrightarrow \frac{\theta(t)}{\theta_0} = e^{\frac{-bt}{2m}}$$

$$5.40° = 6° e^{-\frac{b(25.6)}{2(1)}} \qquad \ln\left(\frac{\theta(t)}{\theta_0}\right) = \frac{-bt}{2m}$$

$$\ln 0.9 = \ln e^{\frac{-b(25.6)}{2}}$$

$$b = -\left(\frac{\ln\left(\frac{\theta(t)}{\theta_0}\right)2m}{t}\right)$$

$$b = -\left(\frac{2\ln 0.9}{25.6}\right)$$

$$b = 8.231290286\times10^{-3}$$

$$b = 8.23\times10^{-3} \quad \boxed{B)}$$

24.

$m_r = m$ $\quad L = 100\text{cm} = 1\text{m}$

$m_s = 2m$

$\text{Torque}_{rock} = mgx$

$\text{Torque}_{stick} = 2mg\left(\frac{L}{2} - x\right)$

$$mgx = 2mg\left(\frac{100}{2} - x\right)$$

$$\frac{mgx}{2mg} = 50 - x$$

$$x = 50 - \frac{x}{2}$$

$$\frac{3}{2}x = 50$$

$$x = 33.\overline{3}\text{ cm} \quad \boxed{B)}$$

25.

$m_1 = m,\ r_1 = r$

$m_2 = 4m,\ r_2 = \frac{1}{2}r$

Taking the moment of inertia:

$$I = m(r\sin\theta)^2$$

$$I = mr^2\sin^2\theta$$

Finding I_1:

$$I_1 = mr^2\sin^2\theta$$

Finding I_2:

$$I_2 = 4m\left(\tfrac{1}{2}r\right)^2\sin^2\theta$$

$$I_T = I_1 + I_2$$

$$= mr^2\sin^2\theta + 4m\left(\tfrac{1}{2}r\right)^2\sin^2\theta$$

$$= mr^2\sin^2\theta + mr^2\sin^2\theta$$

$$I_T = 2mr^2\sin^2\theta \quad \boxed{B)}$$

26.

$d = 0.35L$

Using the Parallel axis theorem:

$$L_{eq} = \frac{I}{md} \qquad I = I_{cm} + md^2 \qquad *d = dL$$

$$L_{eq} = \frac{\frac{127}{1200}ML^2}{m\cdot(0.5-0.35)L} \qquad I = \frac{mL^2}{12} + md^2$$

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

$$L_{eq} = \frac{127}{180}L \qquad I = mL^2\left(\frac{1}{12} + \frac{9}{400}\right)$$

$$L_{eq} = \frac{127}{180}(1) \qquad I = \frac{127}{1200}ML^2$$

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

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

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

$$f = \frac{1}{2\pi\sqrt{\frac{L_{eq}}{g}}} \rightarrow f = \frac{1}{2\pi\sqrt{\frac{127/180}{9.8}}}$$

$f = 0.593154134$ Hz

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

27.

$F = 2.450 \qquad m = \frac{F}{g} \Rightarrow m = \frac{2.450}{9.8} \Rightarrow m = 0.25\text{kg}$

$T = 0.638$ s

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

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

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

$k = 24.24702096$ N/m

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

28.

$m = 60\text{kg}$ $F = 400N$

$F_{Net} = 400 - 60(9.8)$

$F_{Net} = -188N$

$$F = ma$$

$$a = \frac{F}{m}$$

$$a = \frac{-188}{60}$$

$a = -3.13\text{m/s}^2$ $\boxed{A)}$

$a = 3.13\text{m/s}^2$ downwards

29.

$$K_E = \frac{1}{2}I\omega^2$$

$$K_{E_{sphere}} = K_{E_{cylinder}}$$

$$I_{sphere} = \frac{2}{5}MR^2 \qquad I_{cylinder} = \frac{1}{2}MR^2$$

$$\frac{1}{2}\left(\frac{2}{5}MR^2\right)\omega^2_{sphere} = \frac{1}{2}\left(\frac{1}{2}MR^2\right)\omega^2_{cylinder}$$

$$\omega^2_{cylinder} = \frac{\frac{2}{5}MR^2}{\frac{1}{2}Mr^2}\omega^2_{sphere}$$

$$\omega_{cylinder} = \sqrt{\frac{4}{5}}\,\omega_{sphere}$$

$\omega_{cylinder} = \frac{2}{\sqrt{5}}\omega_{sphere}$ $\boxed{D)}$

30.

$m = 0.200\text{kg}$

$V_i = -20\text{m/s}$, $V_f = 12\text{m/s}$

Towards the wall. Away from the wall

$t = 60\text{ms} = 0.06\text{s}$

$$F = m\frac{\Delta v}{\Delta t}$$

$$F = 0.200\cdot\left(\frac{12-(-20)}{0.06-0}\right)$$

$F = 106.\overline{6}$ N

$F = 107N$ $\boxed{B)}$

31.

$m = 7\text{kg}$

$F(x) = 6N - \left(2\frac{N}{m}\right)x + \left(6\frac{N}{m^2}\right)x^2$

Using work:

$$W = \int F(x)$$

$$W = \int 6N - 2\frac{N}{m}x + 6\frac{N}{m^2}x^2\ dx$$

$$W = 6x - x^2 + 2x^3$$

At $x = 9$

$$W = 6(9) - (9)^2 + 2(9)^3$$

$W = 1431J$

Using work again:

$W = E_{kf} - E_{ki} \longrightarrow$ initially at rest

$$\rightarrow W = \frac{1}{2}mv^2$$

$$V = \sqrt{\frac{2W}{m}}$$

$$V = \sqrt{\frac{2(1431)}{7}}$$

$V = 20.22021619$ m/s

$V = 20\text{m/s}$ $\boxed{A)}$