2012 Sectional Physics Exam Solution Set

1. **Correct answer: E**

$$\frac{F_B}{F_A}=\frac{\left(\frac{M_B V_B^2}{R_B}\right)}{\left(\frac{M_A V_A^2}{R_A}\right)}=\frac{\left(\frac{M_B(R_B\omega)^2}{R_B}\right)}{\left(\frac{M_A(R_A\omega)^2}{R_A}\right)}=\frac{\left(\frac{1.50M_A(2.00R_A\omega)^2}{2.00R_A}\right)}{\left(\frac{M_A(R_A\omega)^2}{R_A}\right)}=\frac{(1.50)(2.00)}{1}=\frac{3.00}{1.00}$$

2. **Correct answer: B**

Letting up be positive:

$$\Sigma F_{on\ woman}=M_{woman}a_{woman}$$
$$F_{scale\ on\ woman}-F_{gravity}=M_{woman}a_{woman}$$
$$F_{scale\ on\ woman}=F_{gravity}+M_{woman}a_{woman}$$
$$F_{scale\ on\ woman}=387N+\left(\frac{387N}{9.80\ m/s^2}\right)\left(-1.25\ m/s^2\right)=338N$$
$$\left|F_{woman\ on\ scale}\right|=338N$$

3. **Correct answer: D**

$$\vec{V}_{hail/auto}=\vec{V}_{hail/Earth}+\vec{V}_{Earth/auto}$$
$$\vec{V}_{hail/auto}=25.0\ mph\ \hat{d}+60.0\ mph\left(-\hat{h}\right)$$
$$\left|\vec{V}_{hail/auto}\right|=\sqrt{(25.0)^2+(60.0)^2}\ mph=65.0\ mph$$

4. **Correct answer: B**

Using conservation of energy:

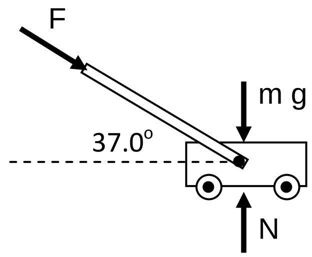
$$KE_i+GPE_i=KE_f+GPE_f$$
$$\frac{1}{2}M(1.75\ m/s)^2+(0)=\frac{1}{2}MV_f^2+M\left(9.80\ m/s^2\right)(-4.00\ m)$$
$$\frac{1}{2}(1.75\ m/s)^2+(0)=\frac{1}{2}V_f^2+\left(9.80\ m/s^2\right)(-4.00\ m)$$
$$V_f=9.03\ m/s$$

5. **Correct answer: E**

$$y(t)=y_i+v_{iy}(t-t_i)+\frac{1}{2}a_y(t-t_i)^2$$
$$-4.00\ m=0.00\ m+(0.00\ m/s)(t-0.00\ s)+\frac{1}{2}\left(-9.80\ m/s^2\right)(t-0.00\ s)^2$$
$$t=0.904\ s$$

6. Correct answer: C

$$\Sigma F_{vertical} = 0$$
$$-F\sin(37.0^o) - m\cdot g + N = 0$$
$$N = m\cdot g + F\sin(37.0^o)$$
$$N = (19.7\ kg)(9.80\ m/s^2) + 234\ N\cdot\sin(37.0^o)$$
$$N = 334\ N$$

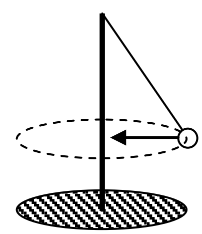


7. Correct answer: C

Impulse and momentum have an equivalent set of units

$$F = ma = m\frac{\Delta v}{\Delta t}$$
$$F\Delta t = m\Delta v$$
$$\text{Impulse} = \text{change in momentum}$$
$$\text{N}\cdot\text{s} = \frac{\text{kg}\cdot\text{m}}{s}$$
$$\frac{\text{kg}\cdot\text{m}}{s^2}\cdot s = \frac{\text{kg}\cdot\text{m}}{s}$$
$$\frac{\text{kg}\cdot\text{m}}{s} = \frac{\text{kg}\cdot\text{m}}{s}$$

8. Correct answer: D



The net force is toward the center of the tether ball's circular orbit. Since the ball is moving in a circular orbit at constant speed, it has an acceleration toward the center of the circle.

9. Correct answer: A

Since no horizontal forces act on the bumblebee-pencil system, its momentum is conserved.

$$\text{initial system mometum} = \text{final system momentum}$$
$$M_{bumblebee}\vec{V}_{i,bumblebee} + M_{pencil}\vec{V}_{i,pencil} = M_{bumblebee}\vec{V}_{f,bumblebee} + M_{pencil}\vec{V}_{f,pencil}$$
$$M_{bumblebee}(0) + M_{pencil}(0) = (0.225\ g)\vec{V}_{f,bumblebee} + (5.775\ g)(0.188\ cm/s\ opposite)$$
$$0 = (0.225\ g)\vec{V}_{f,bumblebee} + (5.775\ g)(0.188\ cm/s\ opposite)$$
$$\vec{V}_{f,bumblebee} = -4.83\ cm/s\ opposite$$
$$\left|\vec{V}_{f,bumblebee}\right| = 4.83\ cm/s$$

10. Correct answer: A

$$\left(875.0\frac{rad}{s}\right)\left(\frac{1\,rev}{2\pi\ rad}\right)\left(\frac{60\ s}{1\,\text{min}}\right)=8356\frac{rev}{\text{min}}$$

11. Correct answer: A

Work done on rod - earth system = change in energy of the system

$$-\tau\cdot\Delta\theta=\left(GPE_f+KE_f\right)-\left(GPE_i+KE_i\right)$$

$$-\tau\cdot\Delta\theta=\left(mgy_f+\frac{1}{2}I\omega_f^2\right)-\left(mgy_i+\frac{1}{2}I\omega_i^2\right)$$

$$-1.20\,Nm\cdot\frac{\pi}{2}=\left(0+\frac{1}{2}\left(0.563kg\cdot m^2\right)\omega_f^2\right)-\left(\left(2.64\ kg\right)\left(9.80\ m/s^2\right)\left(0.400\ m\right)+\frac{1}{2}\left(I\right)\left(0^2\right)\right)$$

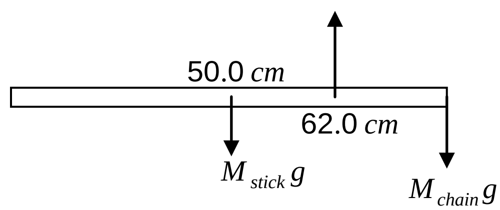
$$1.20\,Nm\cdot\frac{\pi}{2}=\frac{1}{2}\left(0.563kg\cdot m^2\right)\omega_f^2-\left(2.64\ kg\right)\left(9.80\ m/s^2\right)\left(0.400\ m\right)$$

$$\omega_f=5.48\ rad/s$$

12. Correct answer: D

$$\left(M_{chain}\,g\right)\left(100.\ cm-62.0\ cm\right)=\left(M_{stick}\,g\right)\left(12.0\ cm\right)$$

$$\frac{M_{chain}}{M_{stick}}=\frac{12.0}{38.0}=0.316$$



13. Correct answer: B

$$I_1\propto\frac{1}{R_1^2}\qquad I_2\propto\frac{1}{R_2^2}\qquad \frac{I_1}{I_2}=\frac{R_2^2}{R_1^2}$$

$$\frac{3.00\times10^{-6}}{7.34\times10^{-7}}=\frac{R_2^2}{4.35^2}$$

$$R_2=8.79\ m$$

14. Correct answer: E

$$3.750\ m-3.000\ m=one\ wavelength\equiv\lambda=\frac{v}{f}=\frac{343\ m/s}{f}$$

$$f=\frac{343\ m/s}{0.750\ m}=457\ Hz$$

15. Correct answer: C

$$P = \frac{(45.0\ kg)(9.80\ m/s^2)}{\pi(0.0465\ m)^2} = 6.49\times10^4\ \frac{N}{m^2} = 6.49\times10^4\ Pa$$

16. Correct answer: A

$$\text{Heat lost from lead} = \text{Heat gained by water}$$
$$\mathrm{m_{lead}}c_{lead}\left(T_{i,lead} - T_{f,lead}\right) = \mathrm{m_{water}}c_{water}\left(T_{f,water} - T_{i,water}\right)$$
$$(321\ g)\ c_{lead}\left(78.0^o C - T_f\right) = (175\ g)(32.70\ c_{lead})\left(T_f - 23.0^o C\right)$$
$$(321)\left(78.0^o C - T_f\right) = (175)(32.70)\left(T_f - 23.0^o C\right)$$
$$(321)\left(78.0^o C\right) + (175)(32.70)\left(23.0^o C\right) = (321 + 175\times 32.70)T_f$$
$$T_f = 25.9^o C$$

17. Correct answer: B

$$\frac{Q_C}{Q_H} = \frac{T_C}{T_H} = \frac{273.15 - 5.00}{273.15 + 23.0} = 0.9055$$
$$\text{Heat from cold outside} + \text{work done by heat pump} = \text{heat to warm inside}$$
$$Q_C + W = Q_H$$
$$0.9055 Q_H + 384\ J = Q_H$$
$$Q_H = 4.06\ kJ$$

18. Correct answer: E

If the position of zero potential is between the charges:

$$\frac{k\left(5.69\times10^{-8}\right)}{x} + \frac{k\left(-9.18\times10^{-8}\right)}{0.750\ m - x} = 0$$
$$\boxed{x = 0.287\ m} \qquad \text{(which is between the two charges and one of the responses)}$$

If the position of zero potential is on the negative x-axis:

$$\frac{k\left(5.69\times10^{-8}\right)}{-x} + \frac{k\left(-9.18\times10^{-8}\right)}{0.750\ m - x} = 0$$
$$x = -1.22\ m \qquad \text{(possible answer but not one of the responses)}$$

If the position of zero potential is to the right of both charges:

$$\frac{k\left(5.69\times10^{-8}\right)}{x} + \frac{k\left(-9.18\times10^{-8}\right)}{x - 0.750\ m} = 0$$
$$x = -1.22\ m \qquad \text{(should be greater than 0.750 m)}$$

19. **Correct answer: E**

$$\vec{\mathbf{E}} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_1^2}\hat{\mathbf{r}}_1 + \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_2^2}\hat{\mathbf{r}}_2$$

$$= \frac{\left(5.69\times10^{-8}\,\text{C}\right)\hat{\mathbf{i}}}{4\pi\left(8.854\times10^{-12}\,\text{C}^2/\left(\text{N}\cdot\text{m}^2\right)\right)\left(0.500\,\text{m}\right)^2} + \frac{\left(-9.18\times10^{-8}\,\text{C}\right)\left(-\hat{\mathbf{i}}\right)}{4\pi\left(8.854\times10^{-12}\,\text{C}^2/\left(\text{N}\cdot\text{m}^2\right)\right)\left(0.250\,\text{m}\right)^2} = 15.2\,\text{kN/C}\,\hat{\mathbf{i}}$$

20. **Correct answer: C**

Average velocity is displacement divided per time to undergo that displacement. The displacement during the motion described is one radius (200. m) east and one radius (200. m) north. Using the x-direction as east and y-direction as north:

$$\bar{\mathbf{v}} = \frac{200.\text{ m }\hat{\mathbf{i}} + 200.\text{ m }\hat{\mathbf{j}}}{10.0\text{ s}} = 20.0\text{ m/s }\hat{\mathbf{i}} + 20.0\text{ m/s }\hat{\mathbf{j}}$$

$$\left|\bar{\mathbf{v}}\right| = \sqrt{\left(20.0\text{ m/s}\right)^2 + \left(20.0\text{ m/s}\right)^2} = 28.3\text{ m/s} \quad \text{and} \quad \theta = \tan^{-1}\frac{v_y}{v_x} = \tan^{-1}\frac{20.0\text{ m/s}}{20.0\text{ m/s}} = 45.0°$$

21. **Correct answer: D**

Average speed id path length divided by the time to travel along path. The path length in problem 20 is one-fourth a circumference of the circular path.

$$\bar{v} = \frac{l}{t} = \frac{\frac{1}{4}\left(2\pi R\right)}{t} = \frac{\frac{1}{2}\pi\left(200.\text{ m}\right)}{10.0\text{ s}} = 31.4\text{ m/s}$$

22. **Correct answer: C**

$$C_x = A_x - B_x = 5.00\cos\left(0.0°\right) - 4.00\cos\left(-36.87°\right) = 1.80$$
$$C_y = A_y - B_y = 5.00\sin\left(0.0°\right) - 4.00\sin\left(-36.87°\right) = -2.40$$
$$C = \sqrt{C_x^2 + C_y^2} = \sqrt{\left(1.80\right)^2 + \left(-2.40\right)^2} = 3.00 \quad \textit{and} \quad \theta = \tan^{-1}\frac{C_y}{C_x} = \tan^{-1}\frac{-2.40}{1.80} = 53.1°$$

23. **Correct answer: D**

$$\text{Situation 1:}\quad F = \left(M + 2m\right)\left(1.00\text{ m/s}^2\right) \qquad \text{Situation 2:}\quad F = \left(M + 3m\right)\left(0.800\text{ m/s}^2\right)$$

$$\Rightarrow \quad \left(M + 2m\right)\left(1.00\text{ m/s}^2\right) = \left(M + 3m\right)\left(0.800\text{ m/s}^2\right) \quad \Rightarrow \quad M = \frac{0.400m}{0.200} = 2.00m$$

24. **Correct answer: B**

The only horizontal forces in the problem are the forces of the billiard balls on each other and their is no vertical component of acceleration. Therefore,

$$\mathbf{F}_{12} = -\mathbf{F}_{21} \quad \Rightarrow \quad F_{12} = F_{21} \quad \Rightarrow \quad m_1 a_1 = m_2 a_2 \quad \Rightarrow \quad a_2 = \frac{m_1}{m_2}a_1 = \frac{0.300\text{ kg}}{0.350\text{ kg}}1.50\text{ m/s}^2 = 1.29\text{ m/s}^2$$

25. **Correct answer: A**

$$\Delta K + \Delta U = 0 \quad \Rightarrow \quad \tfrac{1}{2} m v_f^2 - \tfrac{1}{2} m v_i^2 + mg\Delta h = 0 \quad \Rightarrow \quad \Delta h = d \sin\theta = -\frac{v_f^2 - v_i^2}{2g} \quad \Rightarrow$$

$$\theta = \sin^{-1}\left(-\frac{v_f^2 - v_i^2}{2gd}\right) = \sin^{-1}\left(-\frac{(1.00 \text{ m/s})^2 - (3.00 \text{ m/s})^2}{2(9.80 \text{ m/s}^2)(2.00 \text{ m})}\right) = 11.8°$$

26. **Correct answer: A**

$$F = At^3 \quad \Rightarrow \quad A = \frac{F}{t^3} \quad \Rightarrow \quad \text{Units of } A = \frac{\text{Units of } F}{\text{Units of } t^3} = \frac{\text{kg} \cdot \text{m/s}^2}{\text{s}^3} = \frac{\text{kg} \cdot \text{m}}{\text{s}^5}$$

27. **Correct answer: A**

$$W = Fd\cos\theta = (4.00 \text{ N})(50.0 \text{ m})\cos 60.0° = 100. \text{ J}$$

28. **Correct answer: D**

If the angular velocity of the grinding wheel is constant, the net torque on the wheel must be zero. There are two torques acting on the wheel, the motor and the frictional torque of the metal against the wheel   These must be equal in magnitude to add to zero. . (Note that the normal force of the metal against the wheel causes no torque.)

$$5.00 \text{ N} \cdot \text{m} = \tau_{fr} = RF_{fr} \sin 90° = R\mu F_N \quad \Rightarrow \quad \mu = \frac{5.00 \text{ N} \cdot \text{m}}{RF_N} = \frac{5.00 \text{ N} \cdot \text{m}}{(0.120 \text{ m})(75.0 \text{ N})} = 0.556$$

29. **Correct answer: E**

$$P = \frac{W}{t} \quad \Rightarrow \quad t = \frac{W}{P} = \frac{mg\Delta h}{P} = \frac{(60.0 \text{ kg})(9.80 \text{ m/s}^2)(8.00 \text{ m})}{(300.0 \text{ W})} = 15.7 \text{ s}$$

30. **Correct answer: C**

$$F = kx = (200 \text{ N/m})(0.600 \text{ m}) = 120 \text{ N}$$

31. **Correct answer: B**

The motion described is one-quarter period:

$$\omega_0 = \sqrt{\frac{k}{m}} \qquad \Rightarrow \qquad t = \frac{T}{4} = \frac{1}{4}\frac{2\pi}{\omega} = \frac{\pi}{2}\sqrt{\frac{m}{k}} = \frac{\pi}{2}\sqrt{\frac{3.00 \text{ kg}}{200 \text{ N/m}}} = 0.192 \text{ s}$$

32. **Correct answer: D**

R_1 is in series with the parallel combination of R_2 and R_3:

$$R_{eq} = R_1 + \frac{R_2 R_3}{R_2 + R_3} = 100.\ \Omega + \frac{(200.\ \Omega)(300.\ \Omega)}{(200.\ \Omega) + (300.\ \Omega)} = 220.\ \Omega$$

33. **Correct answer: B**

The induced voltage in an inductor is such that it would cause a current to flow in the circuit that would oppose the change in current in the inductor. Under the given circumstances, that would be consistent with the left end of the inductor being at a higher voltage than the right end to push current through the external circuit that would flow from right to left in the inductor.

34. **Correct answer: B**

The focal length of a mirror is one-half the radius of curvature of the mirror.

35. **Correct answer: E**

The definition of the halflife of an isotope is the amount of time that must pass for one-half of the nuclei to decay. If one-half of the nuclei decay, the activity of the sample also reduces to one-half the original activity.