Physics 40S Exam Review Key

Extended Answer Key

I: Mechanics

1. A truck is traveling down the highway with a constant velocity of 120 km/h. The truck passes a stationary police car at time t = 0. The police car drives after the speeding truck with an acceleration of 10.0 m/s^2.

   a. If the truck does not slow down, how long does it take the police car to catch up with the truck?

Truck

$v = 120\,\text{km/h} = 33.33\,\text{m/s}$

$d = vt = 33.33t$

Police Car

$d = v_i t + \frac{1}{2}at^2 = \frac{1}{2}(10)t^2$

$33.33t = \frac{1}{2}(10)t^2$

$t = 6.67\,\text{s}$

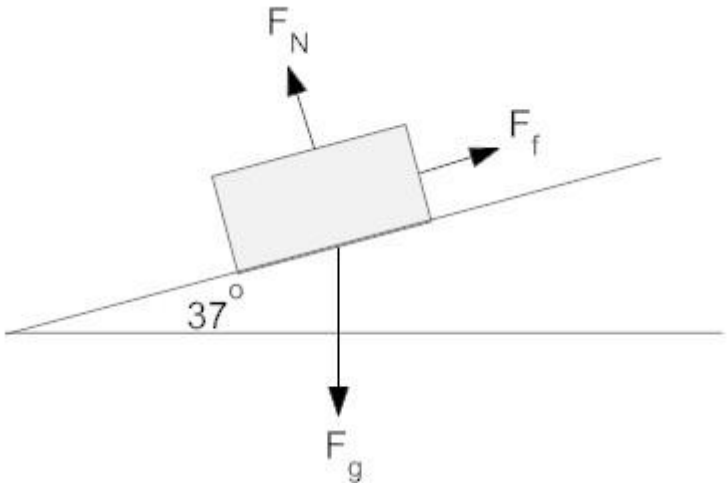
   b. How fast is the police car traveling in **km/h** when it reaches the truck?

$v_f = v_i + at$

$v_f = (5)13.3 = 66.7\,\text{m/s}$

$v_f = 240\,\text{km/h}$

2. A 25 kg block is stationary on a rough inclined plane as shown.



a. Draw and label arrows representing the forces acting on the block.

See Above.

b. Calculate the force of friction acting on the block.

$$\sum F_x = ma = 0$$
$$F_f - F_g \sin\theta = 0$$
$$F_f = mg\sin\theta$$
$$F_f = (25)(9.8)\sin 37$$
$$F_f = 147\ N$$

c. Calculate the coefficient of friction.

$$\sum F_y = ma = 0$$
$$F_N = mg\cos\theta$$
$$F_f = \mu F_N = \mu mg\cos\theta$$
$$\mu = \frac{F_f}{mg\cos\theta} = \frac{147}{25(9.8)\cos 37}$$
$$\mu = 0.75$$

3. A lawnmower is pushed with a force of 150 N at an angle of 42° with the ground. The lawnmower is moving with a constant velocity.

   a. A force is being exerted on the lawnmower. Why is the lawnmower moving with constant velocity?

      The applied force is equal to the frictional force.

   b. Calculate the frictional force acting on the lawnmower.

$$\sum F_x = ma = 0$$
$$F_f - F_a \cos\theta = 0$$
$$F_f = 150\cos 42 = 111\,\text{N}$$

   c. The lawnmower has a mass of 12 kg. Calculate the normal force the ground exerts on the lawnmower.

$$\sum F_y = ma = 0$$
$$F_N - mg - F_a \sin\theta = 0$$
$$F_N = mg + F_a \sin\theta = (12)(9.8) + 150\sin 42$$
$$F_N = 218\ N$$

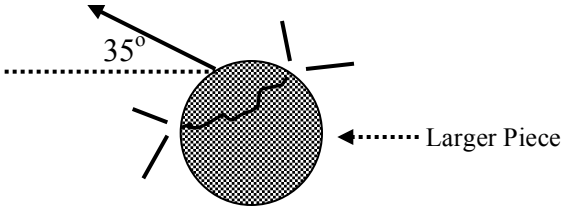
   d. Calculate the coefficient of kinetic friction, μ.

$$F_f = \mu F_N$$
$$\mu = \frac{F_f}{F_N} = \frac{111}{218}$$
$$\mu = 0.51$$

   e. What causes the frictional force on the lawnmower?

      Sample Responses:
      Wheels on the lawnmower
      Grass pushing against the lawnmower

4. A physics student lights a firecracker placed inside of an apple and throws it into the air. When the apple reaches it maximum height it explodes into two unequal pieces.



The larger piece is three times the mass of the smaller piece.

The smaller piece moves upward with a velocity of 60 m/s at an angle of 35^o with the horizontal.

a. In what direction does the larger piece move?

Downwards at an angle of 35^o below the horizontal

b. Calculate the magnitude of the velocity of the larger piece of apple.

$$m_T v_T = m_s v_s + m_L v_L$$
$$0 = m_s v_s + m_L v_L$$
$$m_L = 3m_s$$
$$m_s v_s = 3m_s v_L$$
$$v_L = \frac{v_s}{3} = \frac{60}{3}$$
$$v_L = 20 \text{ m/s}$$

5. An arrow is fired horizontally at the center of a target 20 m away. The arrow leaves the bow with a velocity of 30 m/s.

   a. Calculate the length of time for the arrow to reach the target.

$$v = \frac{d}{t}$$
$$t = \frac{d}{v} = \frac{20}{30}$$
$$t = 0.67 \text{ s}$$

   b. Calculate the displacement of the arrow from the center of the target.

$$v_i = 0$$
$$a = -9.8 \text{ m/s}^2$$
$$y = v_i t + \tfrac{1}{2} a t^2 = \tfrac{1}{2}(-9.8)(0.67)^2$$
$$y = -2.2 \text{ m}$$

   c. Explain what you would do so that you hit the center of the target.

   Aim the arrow upwards. (Other possibilities - move target closer, make arrow go faster.)

6. A 0.1 kg ball attached to a string of negligible mass is rotated horizontally in a circle with a radius of 0.5 m. The ball revolves 10 times in 5 seconds.

   a. Calculate the centripetal force on the ball.

$$T = \frac{5}{10} = 0.5 \text{ s}$$

$$F_c = \frac{m4\pi^2 r}{T^2} = \frac{0.1(4\pi^2)0.5}{0.5^2}$$

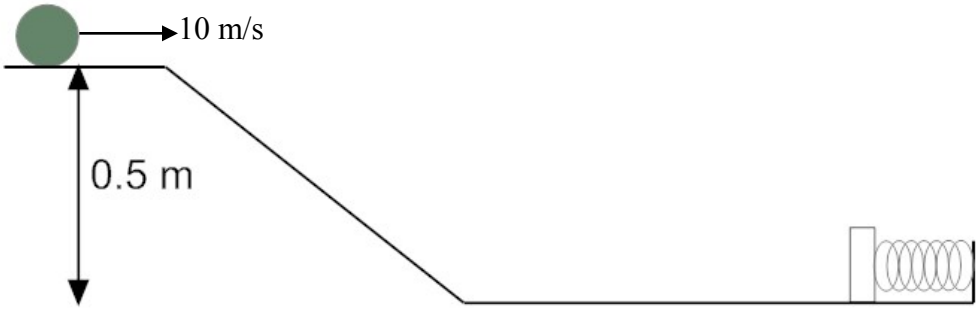
$F_c = 7.9$ N towards the center

   b. Calculate the force of tension in the string.

$$F_T = F_c$$

7.9 N towards the center

7. Consider the following situation:



The ball has an initial velocity of 10 m/s.

a. Calculate the velocity of the ball at the bottom of the ramp.

$$\sum E_b = \sum E_a$$
$$\tfrac{1}{2}mv_1^2 + mgh = \tfrac{1}{2}mv_2^2$$

$$v_2 = \sqrt{v_1^2 + 2gh} = \sqrt{(10)^2 + 2(9.8)(0.5)}$$
$$v_2 = 10.5 \text{ m/s}$$

b. The ball continues along the flat surface and compresses the spring (spring force constant = 200 N/m) a distance of 20 cm. Calculate the mass of the ball. (3 mark)

$$\tfrac{1}{2}mv^2 = \tfrac{1}{2}kx^2$$

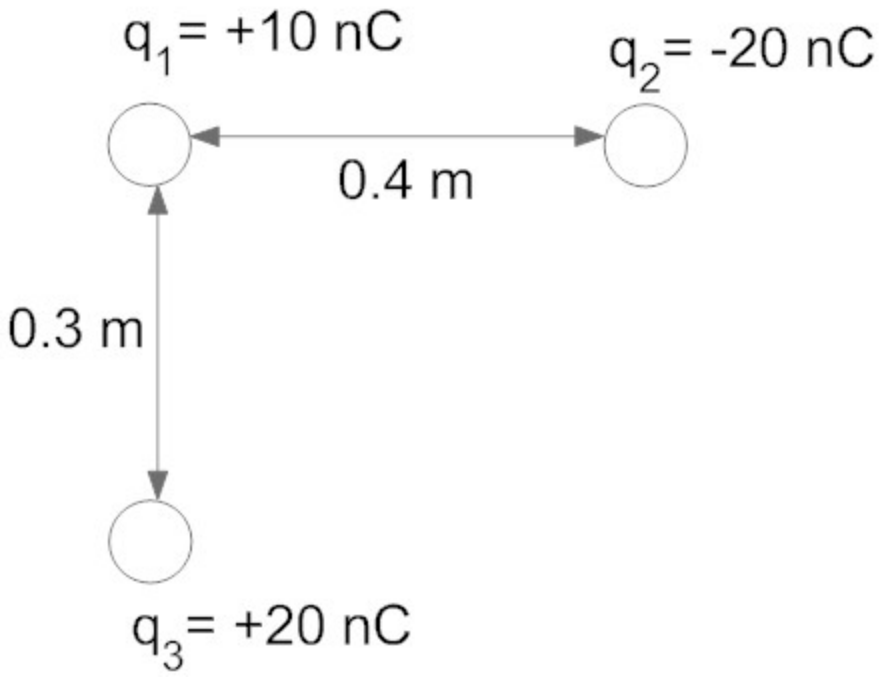
$$m = \frac{kx^2}{v^2} = \frac{200(0.2)^2}{(10.5)^2}$$
$$m = 0.073 \text{ kg}$$

c. Describe the energy conversion that occurs when the spring rebounds to its original shape.

Elastic potential energy is converted to kinetic energy.

II: Fields

8. Three charges are placed as shown:



Calculate the net force on q_3.

$$F_{31} = \frac{kQq}{r^2} = \frac{9\text{x}10^9(10\text{x}10^{-9})(20\text{x}10^{-9})}{0.3^2} = 2\text{x}10^{-5}\text{ N} \quad \text{repulsive}$$

$$F_{32} = \frac{kQq}{r^2} = \frac{9\text{x}10^9(20\text{x}10^{-9})(20\text{x}10^{-9})}{0.5^2} = 1.44\text{x}10^{-5}\text{ N} \quad \text{attractive}$$

$$\theta = \tan^{-1}\left(\frac{0.4}{0.3}\right) = 53^\circ \text{ from the vertical}$$

$$\text{x}: 1.44\text{x}10^{-5}\sin 53 = 1.15\text{x}10^{-5}$$

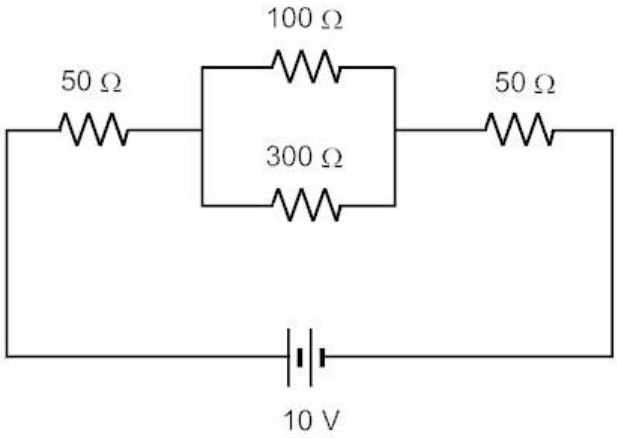
$$\text{y}: 1.44\text{x}10^{-5}\cos 53 - 2\text{x}10^{-5} = -1.13\text{x}10^{-5}$$

$$F_{net} = \sqrt{(1.15\text{x}10^{-5})^2 + (-1.13\text{x}10^{-5})^2} = 1.6\text{x}10^{-5}\text{ N}$$

$$\theta = \tan^{-1}\left(\frac{1.13\text{x}10^{-5}}{1.15\text{x}10^{-5}}\right) = 44^\circ \text{ below the horizontal}$$

III: Electricity

9. Consider the following circuit.



a. Calculate the equivalent resistance of the circuit.

$$R_{parallel} = \left(\frac{1}{100} + \frac{1}{300} \right)^{-1} = 75\ \Omega$$
$$R_{eq} = 50 + 75 + 50 = 175\ \Omega$$

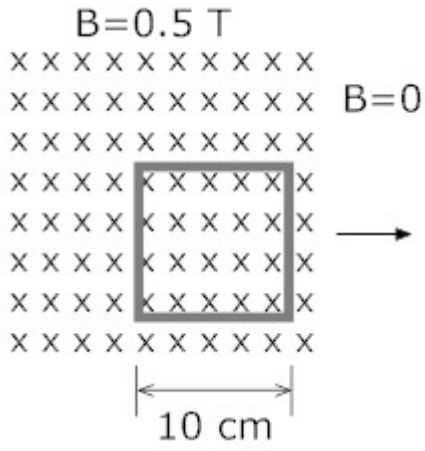
b. Calculate the voltage drop across the 100 Ω resistor.

$$V = IR_{eq}$$
$$I = \frac{V}{R_{eq}} = \frac{10}{175} = 0.057\ \text{A}$$
$$\text{V} = \text{IR}_{\text{parallel}}$$
$$V = (0.057)(75) = 4.3\ \text{V}$$

c. Calculate the current flowing through the 100 Ω resistor.

$$I = \frac{V}{R_{100}} = \frac{4.3}{100} = 0.043\ \text{V}$$

10. A 10 cm by 10 cm square coil of 100 loops is positioned perpendicular to a magnetic field of 0.5 T going into the page.



a. List two ways that an EMF can be induced in the coil.

Any two possibilities:
Change the angle of the coil
Change the magnetic field
Change area of the loop
Change the number of loops

b. The loop is quickly and uniformly pulled from the field (moving perpendicular to the magnetic field) to a region where the magnetic field drops abruptly to zero. It takes 1 second for the whole coil to reach the field-free region. Calculate the induced EMF.

$$V = -\frac{N\Delta\Phi}{\Delta t}$$

$$\Phi = BA\cos\theta$$

After 1 second the entire loop will have been removed from the magnetic field.

Therefore: $\frac{\Delta\Phi}{\Delta t} = \frac{(0 - BA)}{1} = -BA$

$$V = -N(-BA) = -100(-0.5)(.1)^2$$

$$V = 0.5 \text{ V}$$

c. What is the direction of the induced EMF in the wire as it leaves the field?

Clockwise

11. Manitoba Hydro produces AC current in Northern Manitoba using hydroelectric dams and AC generators.

    a. Referring to electromagnetic induction, explain briefly how an AC generator works.

    b. Manitoba Hydro transmits the electricity from Northern Manitoba as direct current on two trunk lines. Why is the electricity transmitted as direct current instead of alternating current?

        Sample responses (only 1 required)*:*
        Less power loss due to resistance over long distances
        Lower cost to build DC transmission lines

    c. Recently Manitoba Hydro decided to build a third trunk line. Discuss the **environmental** and **economic** impacts of building the line referring to the necessity of it and the location.

        Economic reason:
        more power to sell; lower cost of Eastern route

        Environmental reason:
        Western route will avoid the Boreal forest on the East side

Mulitple Choice Key

Question	Answer
1	C
2	D
3	A
4	A
5	D
6	C
7	B
8	D
9	B
10	D
11	A
12	A
13	D
14	A
15	A
16	B
17	D
18	D
19	A
20	C
21	D
22	B
23	C
24	A
25	B
26	C
27	A
28	A
29	C
30	D
31	B
32	B
33	D
34	B
35	D