Name:
Bamfield Number:
Student Number:

Science One Physics Midterm #4

March 23, 2015

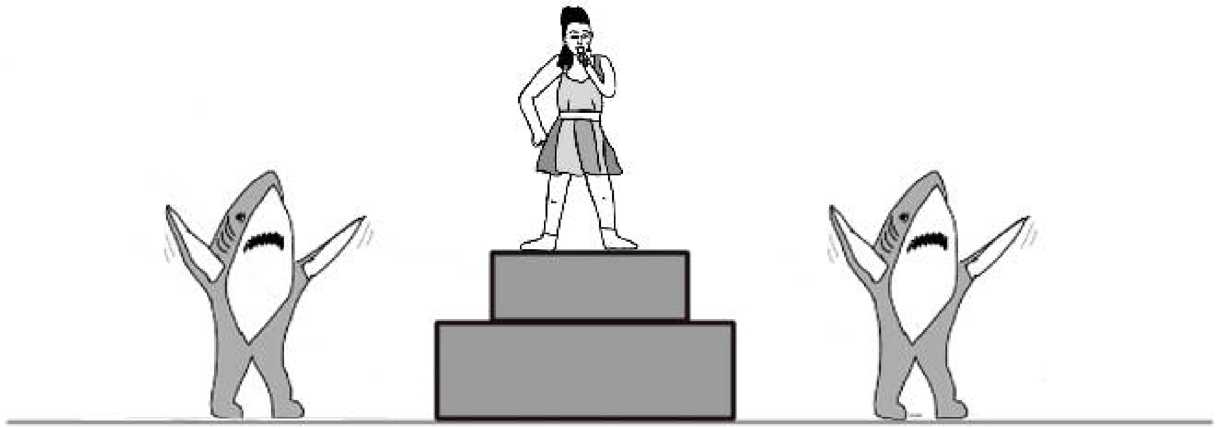
Questions 1-8: Multiple Choice: 2 point each
Questions 9-11: Explain your work: 18 points total

Multiple choice answers:

#1	
#2	
#3	
#4	
#5	
#6	
#7	
#8	

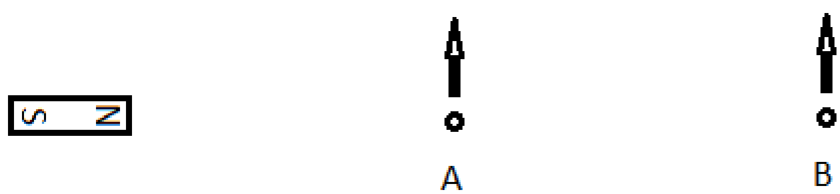
Formula sheet at the back (you can remove it)

Happy 133rd birthday, Emmy Noether!



Question 1: The two dancing sharks are positively charged. If the left shark starts moving backward (into the page) when the right shark starts moving forward (out of the page), the magnetic field at the location of Katy Perry (directly between but above the sharks) will be:

A) To the right B) To the left C) Upwards D) Downwards
E) Up and to the left F) Down and to the right G) The field is zero

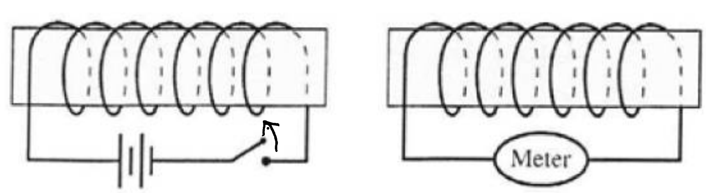


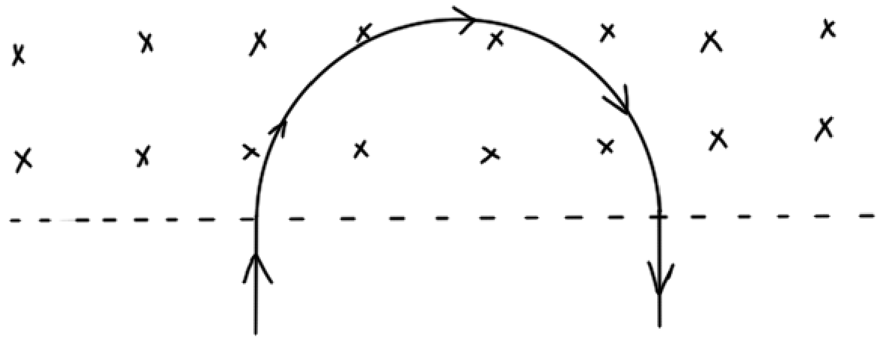
Question 2: The two particles above have equal positive charges and equal upward velocities. The acceleration of particle A (half as far from the magnet) is roughly

A) half as large as the acceleration of particle B
B) twice as large as the acceleration of particle B
C) four times as large as the acceleration of particle B
D) eight times as large as the acceleration of particle B
E) sixteen times as large as the acceleration of particle B
F) the same as the acceleration of particle B, since they are both zero.

Question 3: The switch has been closed for a long time, and then is opened. As the current in the left loop drops to zero, current flows through the meter in the other loop

A) from left to right.
B) from right to left.
C) There is no current.



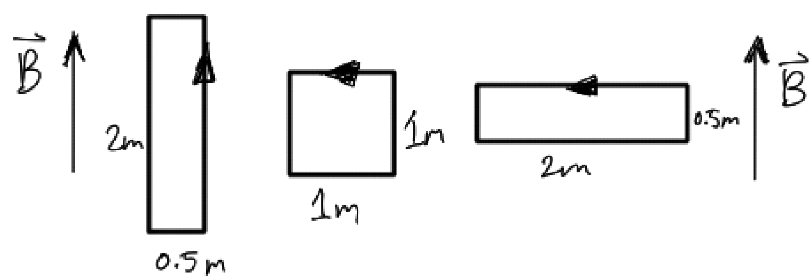


Question 4: A charged particle enters a magnetic field, follows a circular path, and exits the magnetic field again. Assuming there are only magnetic forces on the particle, we can say that the speed of the particle when it exits the field will be

A) Greater than when it entered
B) The same as when it entered
C) Less than when it entered
D) Any of the above are possible depending on the initial velocity of the particle.

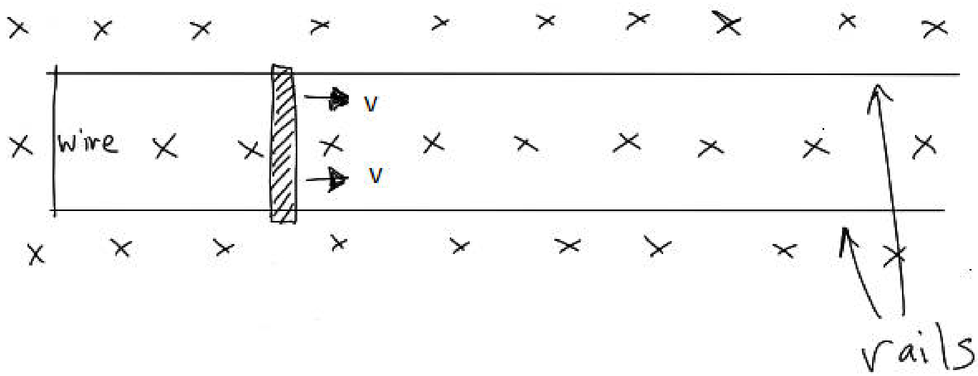
Question 5: If another particle with the same mass and charge but larger velocity enters the field as in question 4,

A) The radius of the circular path will be larger.
B) The radius of the circular path will be smaller.
C) The radius of the circular path will be the same.



Question 6: The three rectangular current loops shown have equal current and are in equal magnetic fields. Which experiences the greatest torque?

A) The first one
B) The second one
C) The third one
D) The first and third have the same torque, larger than the second
E) All the torques are equal



Question 7:

In the picture above, a metal rod slides to the right on conducting rails which are connected by a wire. We can say that:

A) There will be an upward current in the rod.
B) There will be a downward current in the rod.
C) There will be no current in the rod.

Question 8:

In the question above, we can say that the rod will experience

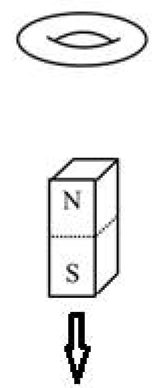
A) a force to the left that increases with time
B) a force to the left that stays constant in time
C) a force to the left that decreases with time
D) a force to the right that increases with time
E) a force to the right that stays constant in time
F) a force to the right that decreases with time
G) no net force

Note: assume that any changes in the rod's speed are due to electromagnetic forces only (i.e. ignore friction).

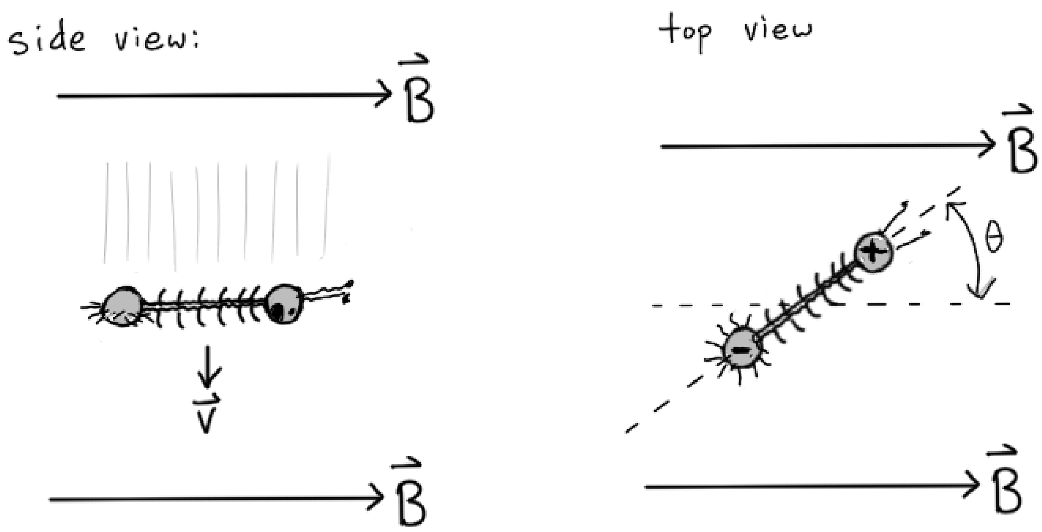
Question 9: Give a brief explanation (2-3 sentences) for each of the following:

a) How can we determine the direction and strength of the magnetic field at some point in space? **(2 points)**

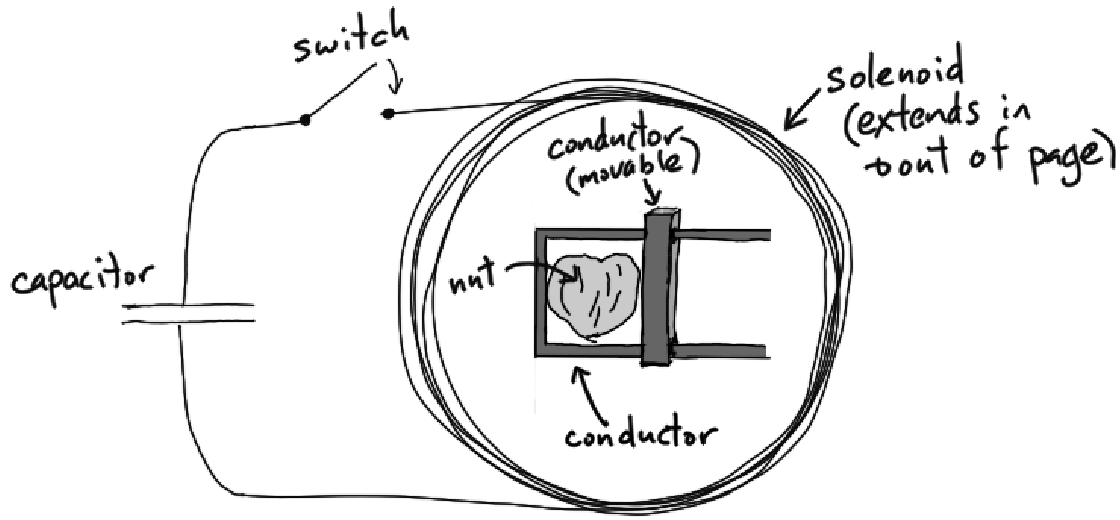
b) In the situation shown, a current is induced in the stationary loop of wire (mmm…metal donut). Explain how/why the current arises. **(2 points)**



c) Why does a permanent magnet stop acting like a magnet if we make it hot enough? **(2 points)**



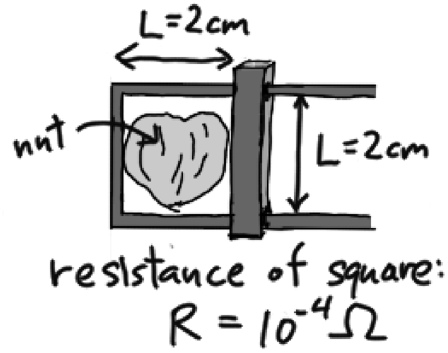
Question 10: A space plankton is falling to Earth at a constant terminal velocity v. The plankton has a narrow body of length L, with a "head" carrying positive charge Q and a tail carrying negative charge –Q. If the plankton is horizontal and θ describes the angle between the plankton's body and the Earth's (horizontal) magnetic field B, determine an equation/equations that describe how θ changes with time. The plankton has mass M and moment of inertia I. You do not need to solve your equation(s).
(6 points)

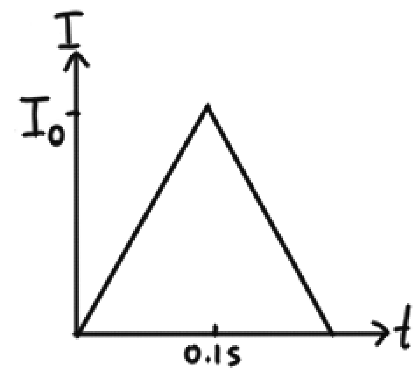


Question 11: Back at Sally's So-So Inventions, Sally has just come up with an idea for a not-entirely-practical electromagnetic nut cracker, depicted above. To crack a nut, Sally closes the switch, which discharges the capacitor through a solenoid. When the capacitor is discharged, a movable conductor inside the coil is observed to slide forcefully along another conductor, cracking the nut.

a) Explain why this nut cracker works **(3 points)**

b) Suppose that the coil has 1000 turns in 10cm, and that the dimensions and resistance of the cracker circuit are as shown at the right. The current in the *solenoid* increases linearly to a maximum value I_0 and then decreases linearly to a maximum value I in time t=0.1s and then decreases linearly to zero, also in the time 0.1s. What value of I_0 is necessary to crack the nut (which requires 1000N of force)? (**3 points**)





FORMULA SHEET

$a = dv/dt$ $v = dx/dt$ $a = v^2/R$

$\mathbf{F} = m\mathbf{a}$
$F_r = -dU/dr$ $W = -\Delta U = -\int \mathbf{F}\cdot\mathbf{dr}$

$\tau = I\,\alpha$ $\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$ $\tau = r_{perp}F = r\,F_{perp} = r\,F\sin(\theta)$

$\mathbf{F} = q\mathbf{E}$ $U = q\,V$
$E_r = -dV/dr$ $\Delta V = -\int \mathbf{E}\cdot\mathbf{dr}$

$E = kq/r^2$ $E = \eta/(2\varepsilon_0)$ $E = 2kp/r^3$ $p = qs$
$\text{Flux} = Q_{enc}/\varepsilon_0$

$k = 9 \times 10^9\ \text{N m}^2/\text{C}^2$ $\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2/(\text{N m}^2)$ $\mu_0 = 4\pi \times 10^{-7}\ \text{T m / A}$

$\mathbf{B} = (\mu_0/4\pi)\, q\, \mathbf{v} \times \mathbf{r} / r^3$ $\mathbf{B} = (\mu_0/4\pi)\, I\, \mathbf{ds} \times \mathbf{r} / r^3$ $B = (\mu_0 / 2\pi)\, I/d$
$B = \mu_0\,(N/L)\,I$ $B = (\mu_0/4\pi)\, 2\,\mu / z^3$ $\int \mathbf{B} \cdot \mathbf{ds} = \mu_0 I$

$\mu = N\,I\,A$

$\mathbf{F} = q\mathbf{E} + q\,\mathbf{v} \times \mathbf{B}$ $\mathbf{F} = I\,\mathbf{l} \times \mathbf{B}$ $\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$ $|\mathbf{F}| = \mu\,|dB/dx|$

$\Phi = \mathbf{B}\cdot\mathbf{A} = BA\cos(\theta)$ $\varepsilon = |d\Phi_m/dt|$ $\int \mathbf{E} \cdot \mathbf{ds} = -\frac{d\,\Phi_m}{dt}$

$V = IR$ $C = Q/V$ $P = IV$

$R = \rho LA$ $\sigma = n_e e^2 \tau/m = 1/\rho$ $v_d = e\,\tau\,E/m$ $I = e\,n_e\,A v_d$

$Q(t) = Q_0 \exp(-t/RC)$