Field Theory Equations:

Gravity	Electric
Force: $F_G = G\dfrac{m_1 m_2}{r^2}$ F_G - Force of gravity (of attraction) (N) G - 6.67x10^{-11} Nm^2kg^{-2} r - distance separating centers (m) $m_{1\&2}$ - the two masses (kg)	Force: $F_E = k\dfrac{q_1 q_2}{r^2}$ F_E - Coulomb Force (of repulsion) (N) k - 8.99x10^9 Nm^2C^{-2} r - distance separating centers (m) $q_{1\&2}$ - the two charges (C)
Field: $g = \dfrac{F}{m}$ g - gravitational field strength (N/kg) F - force exerted by field on the mass (N) m - the mass (kg)	Field: $E = \dfrac{F}{q}$ E - electric field strength (N/C) F - force exerted by field on charge (N) q - the charge (C)
$g = G\dfrac{M}{r^2}$ g - g near a point mass <u>toward</u> mass (N/kg) G - 6.67x10^{-11} Nm^2kg^{-2} M - the mass (kg) r - distance from the point mass (m)	$E = k\dfrac{q}{r^2}$ (not in data packet) E - E near a point charge <u>away</u> from charge (N/C) k - 8.99x10^9 Nm^2C^{-2} q - the charge (C) r - distance from the point charge (m)
Energy: $E_P = mV_g$ E_p - gravitational potential energy (J) V_g - gravitational potential (J/kg) m - the mass (kg) $W = m\Delta V_g$ W - work required to move a mass (J) ΔV_g - change in gravitational potential (J/kg) $\Delta V = (V_{final} - V_{initial})$ m - the mass (kg)	Energy: $E_P = qV_e$ E_p - electrical potential energy (J) V_e - electrical potential (J/C or Volts) q - the charge (C) $W = q\Delta V_e$ W - work required to move a charge (J) ΔV_e - change in electrical potential (J/C or Volts) $\Delta V = (V_{final} - V_{initial})$ q - the charge (C)
Potential: $V_g = -\dfrac{GM}{r}$ V_g - gravitational potential near a point mass (J/kg) G - 6.67x10^{-11} Nm^2kg^{-2} M - the mass (kg) r - distance from the mass (m) $g = -\dfrac{\Delta V_g}{\Delta r}$ g - gravitational field strength (N/kg) ΔV_g - change in gravitational potential (J/kg) Δr - displacement in direction of the field (m)	Potential: $V_e = \dfrac{kq}{r}$ V_e - electrical potential near a point charge (J/C or Volts) k - 8.99x10^9 Nm^2C^{-2} q - the charge (C) r - distance from the charge (m) $E = -\dfrac{\Delta V_e}{\Delta r}$ E - Electric field strength (N/C or V/m) ΔV_e - change in electrical potential (J/C or Volts) Δr - displacement in direction of the field (m)
$E_P = -\dfrac{GMm}{r}$ E_p - gravitational potential energy of two masses (J) G - 6.67x10^{-11} Nm^2kg^{-2} M,m - the two masses (kg) r - distance separating centers (m)	$E_P = \dfrac{kq_1q_2}{r}$ E_p - electrical potential energy of two charges (J) k - 8.99x10^9 Nm^2C^{-2} $q_{1\&2}$ - the two charges (C) r - distance separating centers (m)

IB Physics
16 A-D Group Quiz

Name_______________________________

Show your work, and circle your answers and use sig figs to receive full credit.

$F_G = G\dfrac{m_1 m_2}{r^2}$ $\quad F_E = k\dfrac{q_1 q_2}{r^2}$ - Inverse square force laws

1. What is the force of attraction between a -10.1 μC charge and a +34.1 μC charge if their centers are 67.0 cm apart? Is it a force of attraction or repulsion?

2. At what distance is the force of repulsion between a 2.00 C charge and a 3.00 C charge equal to 4.45 N (1 pound of force, or 16 ounces of force)

3. What is the force of gravity between a 23.0 kg object on the surface of the moon. The moon has a mass of $7.35 x 10^{22}$ kg, and a radius of $1.738 x 10^{6}$ m.

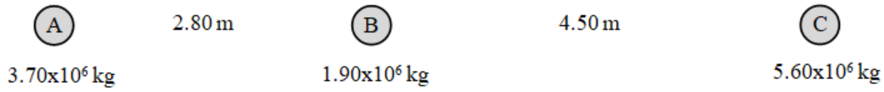
4. 450. Kg wrecking ball experiences a force of attraction of $6.30 x 10^{-10}$ N to a metal sphere that is 15.0 m away. What is the mass of the sphere?

5. Two point masses have a force of attraction of $2.30 x 10^{-12}$ N when they are separated by 56.0 cm. What is their separation if the force of attraction is $5.80 x 10^{-12}$ N?

6. Two point charges have a force of repulsion of 45.3 N when they are 2.30 m separated. What is the force of repulsion if they are separated by only 1.25 m?

7. Two point charges attract each other with a force of 1.40 N when they are 2.20 m apart. How far apart are they if the force of attraction is 5.60 N?

8. Find the net force and direction on masses A, B and C:

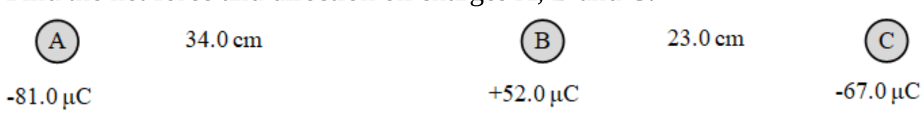


A = __________

B = __________

C = __________

9. Find the net force and direction on charges A, B and C:

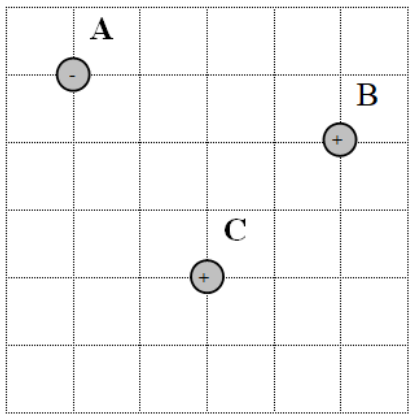


A = __________

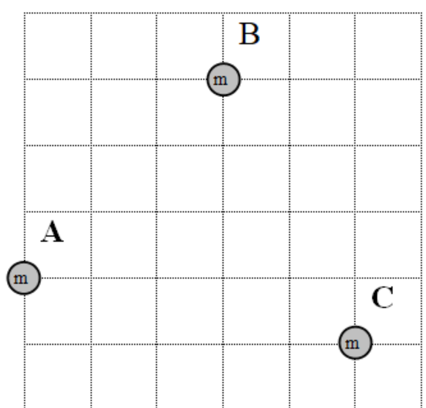
B = __________

C = __________

10. Each grid line is a meter. Charge A is -430. µC, and charge B is +120. µC, and C is +780. µC. Calculate the force on charge C. Draw the force vector and label its magnitude and direction.



11. Each grid line is a meter. Mass A is 1.20×10^6 kg, and mass B is 3.10×10^6 kg, and C is 6.80×10^6 kg. Calculate the force on mass A. Draw the force vector and label its magnitude and direction.



IB Physics
16 E-G Group Quiz

Name______________________________

Show your work, and circle your answers and use sig figs to receive full credit.

$E = \frac{F}{q}$ $g = \frac{F}{m}$ F = ma

1. What is the gravitational force on a 3.40 kg mass in a gravitational field with a strength of 9.81 N/kg?

2. A -140. μC charge experiences a force of 1.50 N to the right. What is the magnitude and direction of the electric field?

3. A 3.20 kg mass on the moon experiences a force of 5.15 N. What is the gravitational field strength on the moon?

4. A 72,100 N/C electrical field to the right exerts what force on a proton? (Force and direction)

5. A proton accelerates North at 9.58×10^8 m/s/s. What is the magnitude and direction of the electric field?

6. An electron is in a 317 N/C electric field to the West. What is the magnitude and direction of its acceleration?

$g = \frac{GM}{r^2}$ $E = \frac{kq}{r^2}$ (← not in data packet - memorize this!!!!)

7. What is the electrical field 82.0 cm to the right of a -2.10 μC charge? (Magnitude and direction)

8. Where is the electrical field 1.25×10^4 N/C straight up in the proximity of a 13.0 μC charge. (Location and distance)

9. I am 2.15 m to the left of an unknown charge, and there is an electric field of 1.65×10^5 N/C to the right. What is the magnitude and polarity of the charge? (How many C, and is it + or -)

10a. What is the gravitational field on the surface of a planet with a mass of 1.60×10^{23} kg, and a radius of 1.85×10^6 m?

10b. What is the gravitational field 3.50 m to the left of a (very dense) mass of 6.40×10^{12} kg? (Magnitude and direction)

11. Where in the proximity of a 5.00 kg shot put is the gravitational field 2.08×10^{-11} N/kg to the right? (Location and distance)

12. I am 15.0 m to the right of an unknown mass and there is a gravitational field of 2.16 N/kg due to the mass. Which direction is the field, and what is the mass?

13. Find the gravitational field at p and q:

m $\quad$ 3.40×10^6 m $\quad$ (p) $\quad$ 5.10×10^6 m $\quad$ m $\quad$ 3.60×10^6 m $\quad$ (q)

1.20×10^{24} kg $\quad$ 9.40×10^{24} kg

p = ___________

q = ___________

14. Find the electric field at p and q:

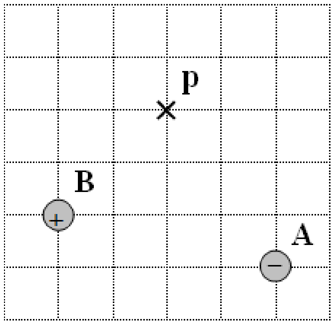
(p) $\quad$ 12.0 m $\quad$ + $\quad$ 23.0 m $\quad$ - $\quad$ 11.0 m $\quad$ (q)

+4.50 μC $\quad$ -5.30 μC

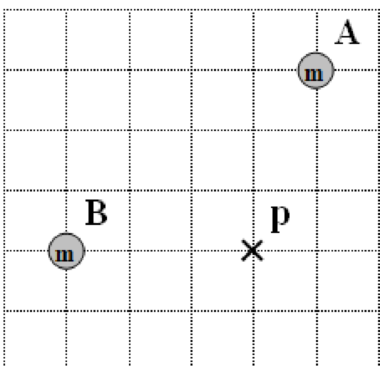
p = ___________

q = ___________

15. Find the electric field at point p. Draw the electric field vector, and label its magnitude and direction. Charge A is -3.20 μC, B is +2.40 μC, and each grid line is a meter.



16. Find the gravitational field at point p. Draw the gravitational field vector, and label its magnitude and direction. Mass A is 2.50×10^{12} kg, B is $5.10 \text{xs} 10^{12}$ kg, and each grid line is a meter.



IB Physics
16 HIKLM Group Quiz

Name______________________________

Show your work, and circle your answers and use sig figs to receive full credit.

$E_p = mV_g \qquad E_p = qV_e \qquad W = m\Delta V_g \qquad W = q\Delta V_e$

1. A 1.20 μC charge is moved from a potential of 14,500 V to 11,300 V. What **work** was done?

2. A 45.0 kg mass is moved from a potential of 1.45 J/kg to 5.60 J/kg. What **work** was done?

3. A -390. μC charge is at 5.00 V. If you do +1.50 mJ of work on it, what is the new **potential**?

4. A 16.0 kg mass is at a potential of 100. J/kg. If you do -318 J of work on it, what is the new **gravitational potential**?

5. A charge is moved from 5210 V to 11,150 V of potential. What is the **charge** if the work done was -56.0 mJ?

6. A mass is moved from 104 J/kg to 213 J/kg of gravitational potential. What is the **mass**, if the work done was 2410 J?

$E = -\frac{\Delta V_e}{\Delta r} \qquad g = -\frac{\Delta V_g}{\Delta r}$ (Assume all these fields are <u>uniform</u>)

7. Two horizontal metal plates are separated by 3.50 cm. A 12.0 V power supply is connected with the + side on the top plate, and the – side on the bottom plate. What is the magnitude and direction of the electric field between the plates?

8. Two vertical metal plates have an electric field of 560. V/m to the right between them. If there is a potential of 43.0 V across the plates, what is their separation distance, and which plate is the positive one, the right or the left?

9. Two horizontal metal plates separated by 10.2 cm have an electric field of 2450 V/m downward between them. What is the potential across the plates, and which plate is the negative one?

10. A mass of 5.65 kg is displaced vertically upward a distance of 4.50 m. What is the gravitational field if the work done is +78.0 J? (Find the change in Gravitational potential, then use that to find the field)

$E = \frac{F}{q}$ $g = \frac{F}{m}$ $E = -\frac{\Delta V_e}{\Delta r}$ $g = -\frac{\Delta V_g}{\Delta r}$ $W = m\Delta V_g$ $W = q\Delta V_e$ (Assume all these fields are uniform)

11. Point A has a gravitational potential of 563 J/kg, and point B has a potential of 237 J/kg. They are separated in a uniform gravitational field by 67.0 m of vertical distance. What is the field strength? Does the field point toward A or B? What force in what direction does it exert on a 17.0 kg mass? What would be the change in the potential energy of the mass if we moved it from point A 12.0 m toward B? Is it an increase or decrease?

12. If you move 15.0 m South in a uniform electric field, your electrical potential increases by 45,300 V. What is the magnitude and direction of the electrical field? If moving a charge 3.00 m to the North increases the potential energy of that charge by +48.0 J, what is that charge, and is it positive or negative? What force does the field exert on the charge?

13. A uniform gravitational field exerts a force of 45.0 N on a 1.60 kg mass away from point B and toward point A. Point B is vertically displaced from point A by 23.1 m. What is the magnitude and direction of the gravitational field strength? What is the change in potential if we move from B to A? What would be the change in potential energy if we were to move the mass from B to A? Is it an increase or decrease? If A is at a potential of 154 J/kg, what is the potential at B?

14. The electric potential (voltage) changes from -127 V to -682 V when we move 92.0 m to the East in a uniform electric field. What is the magnitude and direction of the electric field? What force does it exert on a -390. μC charge? What would be the change in potential energy if we moved the -390. μC charge 15.0 m to the West? Is it an increase or decrease?

$E = \frac{F}{q}$ $g = \frac{F}{m}$ $E = -\frac{\Delta V_e}{\Delta r}$ $g = -\frac{\Delta V_g}{\Delta r}$ So Eq = mg, since E = V/r these are (V/r)q = mg…

15. Two parallel plates are separated by 15.0 cm. A 0.190 gram piece of Styrofoam is suspended between the plates against gravity by a voltage of 213 V from one side to the other. The top plate is positive. What is the charge on the Styrofoam? (is it + or -???)

16. A 0.240 gram piece of Styrofoam with a charge of +1.30 μC is suspended between two parallel plates separated by 10.0 cm. What is the voltage across the plates? Which plate is the positive one, the top or the bottom?

$V_e = \frac{kq}{r}$ or $V_g = -\frac{GM}{r}$

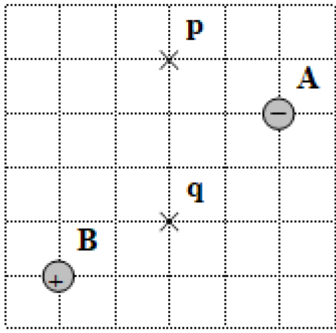
17. What is the voltage 0.340 m from the center of a -12.0 μC charge?

18. An 18.0 cm radius Van de Graaff generator dome has a potential of -40,000 V at its surface. What is the charge on the dome?

19. What is the gravitational potential at the surface of the moon? It has a radius of 1.738×10^6 m and a mass of 7.35×10^{22} kg.

20. At what distance from the center of the earth (m = 5.97×10^{24} kg) is the gravitational potential -1000. J/kg?

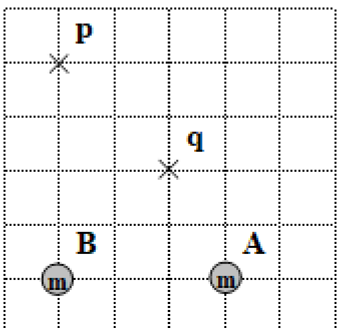
21a. Find the electric potential **at point p and point q**. Charge A is -6.10 µC, B is +4.30 µC, and each grid line is a meter.



Vp	-1.59E+04	V
Vq	-2.10E+03	V
Wpq	1.447	J

21b. What work would you do to move a +105 µC charge from p to q?

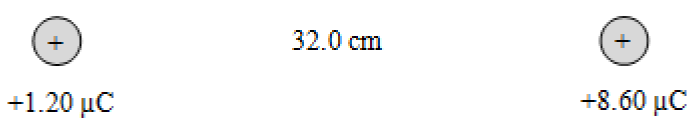
22a. Mass A is 6.30×10^{12} kg, mass B is 5.2×10^{12} kg. Find the gravitational potential at point p and q:



Vp	-170.8	J/kg
Vq	-310.6	J/kg
Wqp	237.7	J

22b. What work would it take to move a 1.70 kg mass from point q to point p?

23. How much work would you need to do to move the 8.60 µC charge so that it is only 20.0 cm from the other charge?
(0.174 J)



24. How much work to move the 15.0 kg mass to exactly the center between the other two masses? (1.14×10^9 J)

Physics Millikan Prep Lab

1. All of these numbers are the product of a random integer and approximately the same non-integer.

40.9475	45.9661	16.2458	29.9228	27.2959
35.538	35.1581	18.9561	35.1041	32.482
27.3335	27.1694	29.9297	40.6765	24.413
27.2691	24.4337	38.0671	19.0247	21.6272
30.0691	24.411	10.9304	21.8267	29.7689
35.1612	27.028	24.4105	27.233	38.0465
29.7615	29.8704	40.6529	29.9329	35.0964
38.3087	29.8171	29.9978	19.1271	46.3732
37.9816	27.29	30.0056	35.4709	27.0478
38.0714	16.3893	32.7231	21.8214	24.3537

•On the reverse I have sorted them and made a histogram of them
•What is the step size? (The non-integer) (High step-low step divided by the # of upward transitions or steps)
•What is the uncertainty in your guess? (•The uncertainty will be the range/2 of the most populous step, divided by the number of steps you used to determine the step size.)

2. •Show the derivation of an equation for **q** - the charge on a sphere in terms of **ρ** - the density of the sphere, **r** - the radius of the sphere, **d** - the separation of the plates, **V** - the voltage applied to the plates, and **g** - the acceleration of gravity. •Use dimensional analysis (plug in the units to show they cancel) to check your answer. Show this

Useful formulas:
F = m**g**, F = E**q**, **V** = E**d**, Volume of a sphere = $4/3\pi \mathbf{r}^3$, **ρ** = m/Volume

$$\rho(\tfrac{4}{3}\pi r^3)g = \left(\frac{V}{d}\right)q$$

Units for Dimensional analysis: (ρ:kg/m^3)(r:m)(g:N/kg)(V:Nm/C)(q:C)(d:m)

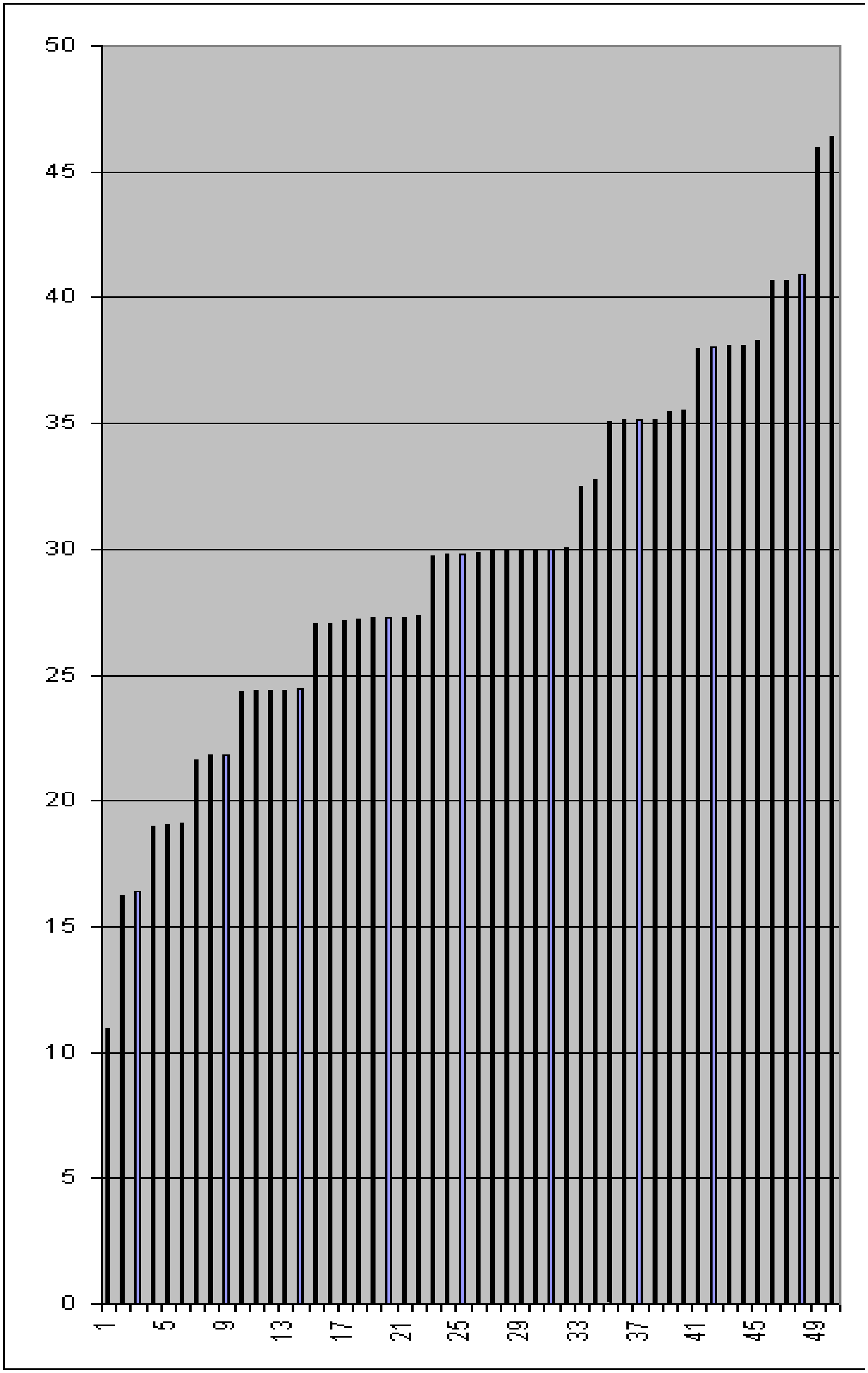
3. •Show the derivation of an equation for **r** - the radius of a sphere in terms of **η** - the viscosity of air, **v** - the terminal velocity of a sphere, **g** - the acceleration of gravity, and **ρ** - the density of a sphere. •Use dimensional analysis (plug in the units to show they cancel) to check your answer. Show this

Useful formulas:
F = m**g**, F = 6πη**rv**, Volume of a sphere = $4/3\pi \mathbf{r}^3$, **ρ** = m/Volume

$$\rho(\tfrac{4}{3}\pi r^3)g = 6\pi\eta r v$$

Units for Dimensional analysis: (ρ:kg/m^3)(r:m)(g:N/kg)(η:Ns/m^2)(v:m/s)

	Sorted
1	10.9304
2	16.2458
3	16.3893
4	18.9561
5	19.0247
6	19.1271
7	21.6272
8	21.8214
9	21.8267
10	24.3537
11	24.4105
12	24.411
13	24.413
14	24.4337
15	27.028
16	27.0478
17	27.1694
18	27.233
19	27.2691
20	27.29
21	27.2959
22	27.3335
23	29.7615
24	29.7689
25	29.8171
26	29.8704
27	29.9228
28	29.9297
29	29.9329
30	29.9978
31	30.0056
32	30.0691
33	32.482
34	32.7231
35	35.0964
36	35.1041
37	35.1581
38	35.1612
39	35.4709
40	35.538
41	37.9816
42	38.0465
43	38.0671
44	38.0714
45	38.3087
46	40.6529
47	40.6765
48	40.9475
49	45.9661
50	46.3732



IB Physics
FA 16.1 - Vector Force

Name____________________________

Favorite Animated Movie____

Show your work, and circle your answers and use sig figs to receive full credit.

When you have finished this, go to the website and check your answers. If you got a problem wrong, cross it off on the front, and do it correctly on the back.

1. What is the force on, and the electric field surrounding (magnitude and direction) an electron if it is accelerated upward at 5.20×10^{15} m/s/s?

2. A 1.50-gram object is suspended against gravity between two horizontal parallel plates that are 5.20 cm apart. What charge does the object have if this requires 537 V to accomplish? If the top plate is negative, is the charge positive or negative?

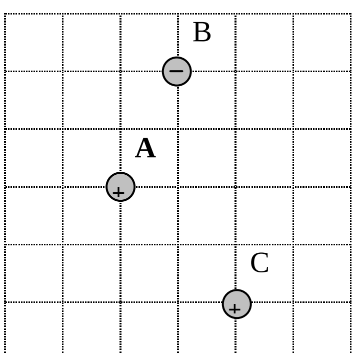
3. Two point masses have a force of attraction of 2.30×10^{-12} N when they are separated by 56.0 cm. What is their separation if the force of attraction is 5.80×10^{-12} N?

4. Find the net force and direction on mass **A** and mass **B**:

A = __________

B = __________

5. Each grid line is a meter. Charge A is +160. µC, and charge B is -210. µC, and C is +630. µC. **Calculate the force on charge A**. Draw the force vector and label its magnitude and direction.



Problems from A16.1: Vector Forces

F = ma $E = \dfrac{F}{q}$ $g = \dfrac{F}{m}$

1. An electron is in a 2310 N/C electric field to the West. What is its acceleration? Look up the charge and mass in your data packet. (4.06×10^{14} ms^{-2} East)
2. A proton accelerates North at 3.80×10^{12} ms^{-2}. What is the electric field? (3.97×10^{4} N/C North)
3. There is a upward force of 0.0120 N on a charge inside a downward electric field of 450. N/C. What is the charge? Is it positive or negative? (-2.67×10^{-5} C, negative)
4. The planet Xzarr exerts a force of 67.0 N on a 4.50 kg mass. What is the gravitational field strength? (14.9 N/kg)
5. A region in space has a gravitational field strength of 1.40 N/kg. What mass would experience a force of 780. N. (557 kg)

$E = \dfrac{F}{q}$ $g = \dfrac{F}{m}$ $E = -\dfrac{\Delta V_e}{\Delta r}$ (Electrical force upwards = Gravitational force downwards)

6. A 0.310-gram object with a charge of -1.80 µC is suspended against gravity between two horizontal parallel plates. The plates have a voltage of 150. V across them, what is their separation? Which plate is the positive plate? (8.88 cm, top)
7. A 0.980-gram object with a charge of +0.780 µC is suspended against gravity between two horizontal parallel plates that are 3.80 cm apart. What voltage does this require, and which plate is the positive plate? (468 V, bottom)
8. A 0.450-gram object is suspended against gravity between two horizontal parallel plates that are 1.50 cm apart. What charge does the object have if this requires 13.0 V to accomplish? If the top plate is negative, is the charge positive or negative? (5.09 µC, positive)
9. An object with a charge of +4.50 µC is suspended against gravity between two horizontal parallel plates that are 1.4 cm apart. What mass does the object have if this requires 260. V to accomplish? Which plate is positive, the top or the bottom? (8.52 g, bottom)
10. A 2.30 gram object is suspended against gravity between two horizontal parallel plates that are 3.80 cm apart. What charge does the object have if this requires 75.0 V to accomplish? If the positive plate is on the top, is the charge positive or negative? (11.4 µC (1.14×10^{-5} C), negative)

$F_G = G\dfrac{m_1 m_2}{r^2}$ $F_E = k\dfrac{q_1 q_2}{r^2}$ - Inverse square force laws

11. At what distance from the center of a 3.40 µC charge is there a force of 7.80 N on a 1.10 µC charge? Is it attracted or repelled? (6.57 cm, repelled)
12. A -3.80 µC charge is attracted with a force of 45.0 N to another charge that is 56.0 cm away. What is the other charge? Is it positive or negative? (413 µC(4.13×10^{-4} C), positive)
13. At what distance from the center of a 5.97×10^{24} kg planet is the force of attraction on a 6.00 kg mass 23.0 N (1.02×10^{7} m)
14. On the surface of a 7.30×10^{6} m radius planet, there is a 57.0 N force on a 5.10 kg mass. What is the planet's mass? (8.93×10^{24} kg)
15. Two point charges have a force of attraction of 140. N when they are 12.0 m away from each other. What is their force of attraction when they are 17.0 m away from each other? (69.8 N)
16. The force of gravity between two spherical masses is 5.90×10^{-12} N when their centers are separated by 1.80 m. If they are moved so that the force of attraction is 7.80×10^{-12} N, what is their new separation? (1.57 m)
17. Two point charges have a force of repulsion of 56.0 N when they are 45.0 cm from each other. At what separation is the force 98.0 N? (34.0 cm)
18. The force of gravity between two spherical masses is 6.00×10^{-11} N when their centers are separated by 1.10 m. If they are moved so that their separation is 3.20 m, what is the force of attraction? (7.09×10^{-12} N)
19. Two point charges have a force of attraction of 160. N when they are 2.50 m apart. If they are moved so their new force of attraction is 240. N, what is their separation? (2.04 m)
20. Two point masses are attracted by a force of 1.20×10^{-12} N when they are 45.0 cm apart. If they are moved so that they are 150.0 cm apart, what is their new force of attraction? (1.08×10^{-13} N)

21. Linear Arrays:

A. Find the net force and direction on the charges (A: 72.4 N right, B: 111 N left, C: 39.0 N right)

A	23.0 cm	B	35.0 cm	C
-17.0 μC		+18.0 μC		+45.0 μC

B. Find the net force and direction on the charges: (A: 12.2 N left, B: 91.1 N right, C: 78.9 N left)

A	18.0 cm	B	42.0 cm	C
+11.0 μC		+12.0 μC		-89.0 μC

C. Find the net force and direction on the masses: (A: 39.2 N right, B: 3.10 N left, C: 36.1 N left)

A	5.90 m	B	3.10 m	C
9.80×10^6 kg		1.10×10^6 kg		2.30×10^6 kg

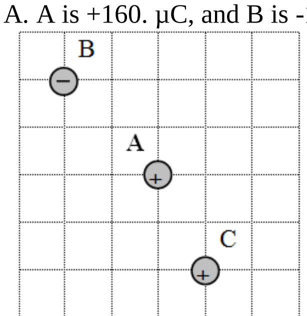
D. Find the net force and direction on the masses: (A: 10.5 N right, B: 11.9 N right, 22.4 N left)

A	6.50 m	B	9.70 m	C
1.40×10^6 kg		3.50×10^6 kg		7.90×10^6 kg

22. Non-Linear Arrays:

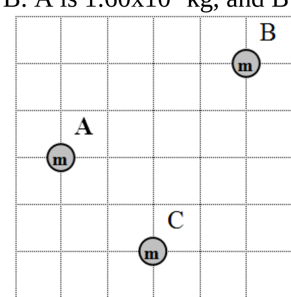
Each grid line is a meter. **Calculate the force on object A**. Draw the force vector and label its magnitude and direction.

A. A is +160. μC, and B is -110. μC, and C is +630. μC.



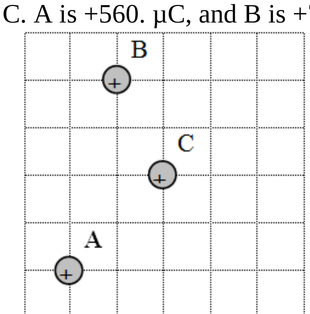
(200. N up and left at 61.6° above the x-axis)

B. A is 1.60×10^6 kg, and B is 2.10×10^6 kg, and C is 6.30×10^6 kg.



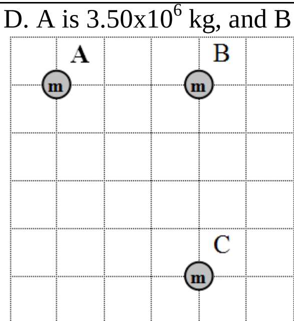
(88.2 N right and down at 38.1° below the x-axis)

C. A is +560. μC, and B is +780. μC, and C is +450. μC.



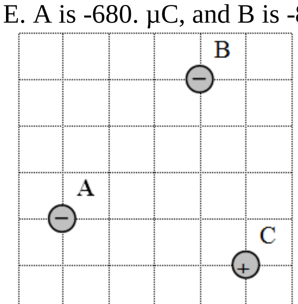
(496 N down and left at 58.9° below the x-axis)

D. A is 3.50×10^6 kg, and B is 2.20×10^6 kg, and C is 8.10×10^6 kg.



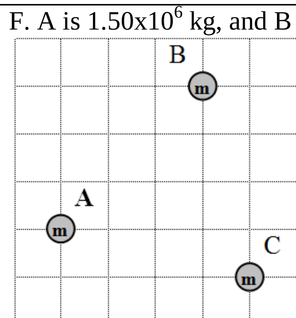
(119 N right and down at 30.6° below the x-axis)

E. A is -680. μC, and B is -890. μC, and C is +670. μC.



(273 N left and up at 85.8° above the x-axis)

F. A is 1.50×10^6 kg, and B is 7.30×10^6 kg, and C is 5.10×10^6 kg.



(61.6 N right and up at 20.3° above the x-axis)