Field Theory Equations:

|  |  |
| --- | --- |
| Gravity | Electric |
| Force:  FG - Force of gravity (of attraction) (N)  G - 6.67x10-11 Nm2kg-2  r - distance separating centers (m)  m1&2 - the two masses (kg)  Field:  g - gravitational field strength (N/kg)  F - force exerted by field on the mass (N)  m - the mass (kg)    g - g near a point mass toward mass (N/kg)  G - 6.67x10-11 Nm2kg-2  M - the mass (kg)  r - distance from the point mass (m) | Force:  FE - Coulomb Force (of repulsion) (N)  k - 8.99x109 Nm2C-2  r - distance separating centers (m)  q1&2 - the two charges (C)  Field:  E - electric field strength (N/C)  F - force exerted by field on charge (N)  q - the charge (C)  (not in data packet)  E - E near a point charge away from charge (N/C)  k - 8.99x109 Nm2C-2  q - the charge (C)  r - distance from the point charge (m) |
| Energy:  Ep - gravitational potential energy (J)  Vg - gravitational potential (J/kg)  m - the mass (kg)    W - work required to move a mass (J)  ΔVg - change in gravitational potential (J/kg)  ΔV = (Vfinal - Vinitial)  m - the mass (kg) | Energy:  Ep - electrical potential energy (J)  Ve - electrical potential (J/C or Volts)  q - the charge (C)    W - work required to move a charge (J)  ΔVe - change in electrical potential (J/C or Volts)  ΔV = (Vfinal - Vinitial)  q - the charge (C) |
| Potential:  Vg - gravitational potential near a point mass (J/kg)  G - 6.67x10-11 Nm2kg-2  M - the mass (kg)  r - distance from the mass (m)    g - gravitational field strength (N/kg)  ΔVg - change in gravitational potential (J/kg)  Δr - displacement in direction of the field (m) | Potential:  Ve - electrical potential near a point charge (J/C or Volts)  k - 8.99x109 Nm2C-2  q - the charge (C)  r - distance from the charge (m)    E - Electric field strength (N/C or V/m)  ΔVe - change in electrical potential (J/C or Volts)  Δr - displacement in direction of the field (m) |
| Ep - gravitational potential energy of two masses (J)  G - 6.67x10-11 Nm2kg-2  M,m - the two masses (kg)  r - distance separating centers (m) | Ep - electrical potential energy of two charges (J)  k - 8.99x109 Nm2C-2  q1&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.**

  - 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 7.35x1022 kg, and a radius of 1.738x106 m.

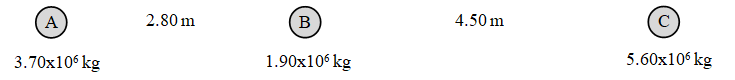
4. 450. Kg wrecking ball experiences a force of attraction of 6.30x10-10 N to a metal sphere that is 15.0 m away. What is the mass of the sphere?

5. Two point masses have a force of attraction of 2.30x10-12 N when they are separated by 56.0 cm. What is their separation if the force of attraction is 5.80x10-12 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:

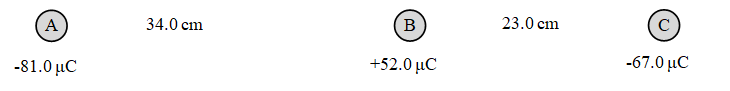


A =

B =

C =

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

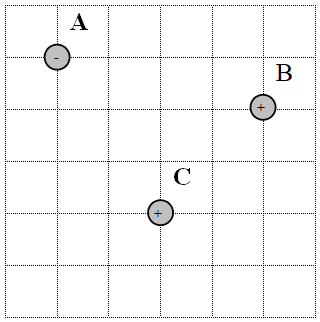


A =

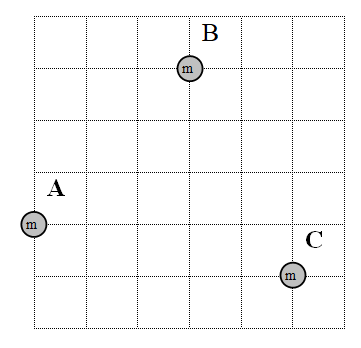
B =

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 1.20x106 kg, and mass B is 3.10x106 kg, and C is 6.80x106 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.**

  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 9.58x108 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?

  (← 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 1.25x104 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 1.65x105 N/C to the right. What is the magnitude and polarity of the charge? (How many C, and is it + or -)

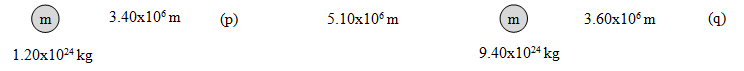
10a. What is the gravitational field on the surface of a planet with a mass of 1.60x1023 kg, and a radius of 1.85x106 m?

10b. What is the gravitational field 3.50 m to the left of a (very dense) mass of 6.40x1012 kg? (Magnitude and direction)

11. Where in the proximity of a 5.00 kg shot put is the gravitational field 2.08x10-11 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:



p =

q =

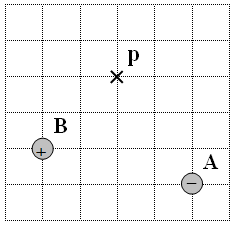
14. Find the electric field at p and q:



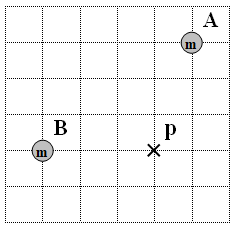
p =

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 2.50x1012 kg, B is 5.10xs1012 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.**

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?

  (Assume all these fields are uniform)

1. 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?
2. 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?
3. 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?
4. 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)

      (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?

    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?

 or 

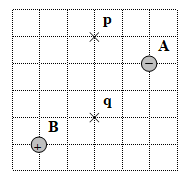
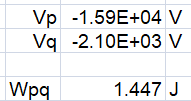
17. What is the voltage 0.340 m from the center of a -12.0 μC charge?

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 1.738x106 m and a mass of 7.35x1022 kg.

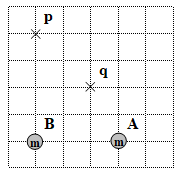
20. At what distance from the center of the earth (m = 5.97x1024 kg) is the gravitational potential -1000. J/kg?

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.



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

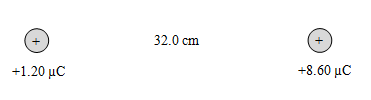
22a. Mass A is 6.30x1012 kg, mass B is 5.2x1012 kg. Find the gravitational potential at point p and q:



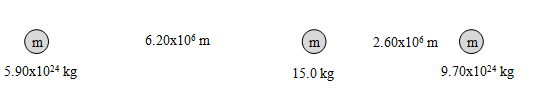
22b. What work would it take to move a 1.70 kg mass from point q to point p?

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? (1.14x109 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 **** - 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**r**3, **** = m/Volume



Units for Dimensional analysis: (:kg/m3)(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 **** - 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 = 6η**rv**, Volume of a sphere = 4/3**r**3, **** = m/Volume



Units for Dimensional analysis: (:kg/m3)(r:m)(g:N/kg)(η:Ns/m2)(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 5.20x1015 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 2.30x10-12 N when they are separated by 56.0 cm. What is their separation if the force of attraction is 5.80x10-12 N?

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

2.60x106 kg

1.80x106 kg

3.70x106 kg

A

8.50 m

B

C

6.30 m

**A =**

35.0 cm

23.0 cm

**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.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | B |  |  |
|  |  |  |  |  |  |
|  |  | **A** |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  | C |  |
|  |  |  |  |  |  |

**Problems from A16.1: Vector Forces**

F = ma  

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. (4.06x1014 ms-2 East)
2. A proton accelerates North at 3.80x1012 ms-2. What is the electric field? (3.97x104 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? (-2.67x10-5 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)

   (Electrical force upwards = Gravitational force downwards)

1. 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)
2. 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)
3. 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)
4. 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)
5. 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 (1.14x10-5 C), negative)

  - Inverse square force laws

1. 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)
2. 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(4.13x10-4 C), positive)
3. At what distance from the center of a 5.97x1024 kg planet is the force of attraction on a 6.00 kg mass 23.0 N (1.02x107 m)
4. On the surface of a 7.30x106 m radius planet, there is a 57.0 N force on a 5.10 kg mass. What is the planet's mass? (8.93x1024 kg)
5. 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)
6. The force of gravity between two spherical masses is 5.90x10-12 N when their centers are separated by 1.80 m. If they are moved so that the force of attraction is 7.80x10-12 N, what is their new separation? (1.57 m)
7. 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)
8. The force of gravity between two spherical masses is 6.00x10-11 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? (7.09x10-12 N)
9. 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)
10. Two point masses are attracted by a force of 1.20x10-12 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? (1.08x10-13 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)  -17.0 μC  +18.0 μC  +45.0 μC  A  35.0 cm  B  C  23.0 cm |
| 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)  +11.0 μC  +12.0 μC  -89.0 μC  A  42.0 cm  B  C  18.0 cm |
| 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)  9.80x106 kg  1.10x106 kg  2.30x106 kg  A  3.10 m  B  C  5.90 m |
| D. Find the net force and direction on the masses: (A: 10.5 N right, B: 11.9 N right, 22.4 N left)  1.40x106 kg  3.50x106 kg  7.90x106 kg  A  9.70 m  B  C  6.50 m |

**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 61.6o above the x-axis) | B. A is 1.60x106 kg, and B is 2.10x106 kg, and C is 6.30x106 kg.    (88.2 N right and down at 38.1o 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 58.9o below the x-axis) | D. A is 3.50x106 kg, and B is 2.20x106 kg, and C is 8.10x106 kg.    (119 N right and down at 30.6o 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 85.8o above the x-axis) | F. A is 1.50x106 kg, and B is 7.30x106 kg, and C is 5.10x106 kg.    (61.6 N right and up at 20.3o above the x-axis) |