**Field Theory Worksheet**

**Vector Force 1: Each grid line is a meter. Charge A is +12.6 x 10-6 C, and charge B is +19.3 x 10-6 C,**

**and C is -25.1 x 10-6 C. Carry at least 4 sig figs for your calculations.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **B** | **y** |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  |  | **x** |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | **A** |  |  |  |  |  |  |  |  |  |  | **C** |
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Calculate the force **on charge A** as a magnitude and a direction. The direction should be a trig angle. Draw the force vector above

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **magnitude** | **trig. angle** | **x-comp** | **y-comp** |
| FBA |  |  |  |  |
| FCA |  |  |  |  |
|  |  | FBA + FCA |  |  |
|  |  |  | Magnitude | Trig Angle |
|  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | charge | x | y |  |  |
| A | 1.26E-05 | -5 | -2 |  |  |
| B | 1.93E-05 | -1 | 6 |  |  |
| C | 2.51E-05 | 6 | -2 |  |  |
|  |  | mag | angle | x | y |
|  | FBA | 2.733E-02 | 243.4 | -1.222E-02 | -2.444E-02 |
|  | FCA | 2.350E-02 | 0 | 2.350E-02 | 0.000E+00 |
|  |  |  | total> | 1.128E-02 | -2.444E-02 |
|  |  |  | Mag | 0.026918 |  |
|  |  |  | angle | 294.8 |  |

**Vector Force 2: Each grid line is a meter. Charge A is +12.6 x 10-6 C, and charge B is +19.3 x 10-6 C,**

**and C is -25.1 x 10-6 C. Carry at least 4 sig figs for your calculations.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  | **B** | **y** |  |  |  |  |  |  |
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|  |  | **A** |  |  |  |  |  |  |  |  |  |  | **C** |
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Calculate the force **on charge B** as a magnitude and a direction. The direction should be a trig angle. Draw the force vector above

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **magnitude** | **trig. angle** | **x-comp** | **y-comp** |
| FAB |  |  |  |  |
| FCB |  |  |  |  |
|  |  | FAB + FCB |  |  |
|  |  |  | Magnitude | Trig Angle |
|  |  |  |  |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | charge | x | y |  |  |
| A | 1.26E-05 | -5 | -2 |  |  |
| B | 1.93E-05 | -1 | 6 |  |  |
| C | 2.51E-05 | 6 | -2 |  |  |
|  |  | mag | angle | x | y |
|  | FAB | 2.733E-02 | 63.43 | 1.222E-02 | 2.444E-02 |
|  | FCB | 3.854E-02 | 311.2 | 2.538E-02 | -2.900E-02 |
|  |  |  | total> | 3.760E-02 | -4.562E-03 |
|  |  |  | Mag | 0.0378757 |  |
|  |  |  | angle | 353.1 |  |

**Linear Arrays of charge.**

**LA 1.** A +12.5 μC charge is 120. cm to the right of a +35.2 μC charge. (Draw yourself a picture)

a. What is the force on the leftmost charge? What direction is it?

(2.75 N to the left)

b. What is the electric field 45.0 cm to the right of the leftmost charge? What direction?

(1.36x106 N/C to the right)

c. What is the electric field 52.0 cm to the right of the rightmost charge?

(5.23x105 N/C to the right)

d. Where relative to the leftmost charge is the electric field zero?

(75.192 cm to the right of the leftmost charge)

**LA 2.** A +24.0 μC charge is 420. cm to the left of a -72.0 μC charge. (Draw yourself a picture)

a. What is the force on the rightmost charge? What direction is it?

(0.881 N to the left)

b. What is the electric field 500. cm to the left of the leftmost charge? What direction?

(983 N/C to the left)

c. What is the electric field 150. cm to the right of the leftmost charge?

(1.85x105 N/C right)

d. Where relative to the leftmost charge is the electric field zero?

(573.731 cm to the left of the leftmost charge)

**A. Electrostatics - Each grid line is a meter. Charge A is +14.4 x 10-6 C, and charge B is -23.1 x 10-6 C. Find the electric field at the origin. Draw the vector as an arrow with its tail on the origin, and label the angle you calculated. Carry at least 4 sig figs for your calculations.**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  | **y** |  |  |  |  |  |  |
|  |  |  |  | **A** |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  | **Q** |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  | **B** |
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|  |  |  |  |  |  |  |  |  |  |  |  |  | **x** |
|  | **P** |  |  |  |  |  |  |  |  |  |  |  |  |
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1. Find the Electric field vector at the origin. Fill this in:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **magnitude** | **trig. angle** | **x-comp** | **y-comp** |
| EA |  |  |  |  |
| EB |  |  |  |  |
|  |  | EA + EB |  |  |
|  |  |  | Magnitude | Trig Angle |
|  |  |  |  |  |

2. What is the electric potential at location P? What is the electric potential at location Q? What is the potential at the origin?

3. If I were to move 6.71x10-6 C of charge from Q to P, how much work would I have to do?

4. If I move 6.71x10-6 C from Q to the origin, what work do I do? Then move it from the origin to point P – How much work is that? How does the total of both moves compare to the answer in 3.?

Answers to A

1:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | q | x | y | mag | trig angle |
| A | 1.44E-05 | -3 | 5 | 3807.53 | 300.96 |
| B | -2.31E-05 | 6 | 3 | 4614.87 | 26.57 |
|  |  |  |  |  |  |
| Ea | EA | 1958.96 | -3264.9 |  |  |
|  | EB | 4127.66 | 2063.83 |  |  |
|  | EA + EB | **6086.62** | **-1201.10** | **N/C** |  |
|  |  | mag | Trig Angle |  |  |
|  |  | **6204** | **348.84** |  |  |

2 and 3:

|  |  |  |
| --- | --- | --- |
| 2. Vp | 2.88E+03 | V |
| Vq | -7.46E+04 | V |
| origin | -8.76E+03 | V |
| 3. Wqp | 5.20E-01 | J |

|  |  |  |
| --- | --- | --- |
| 4. Wq-origin | 4.42E-01 | J |
| Worigin-p | 7.81E-02 | J |

It adds up to the same thing (0.520 J) – it doesn’t matter how you get from Q to P.**Field Theory**

**B. Gravity - Each grid line is a meter. Mass A is 6.56 x 1012 kg, and mass B is 4.81 x 1012 kg. Find the gravitational field at the origin. Draw the vector as an arrow with its tail on the origin, and label the angle you calculated. Carry at least 4 sig figs for your calculations.**

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|  |  |  |  |  |  |  | **y** |  |  |  |  |  |  |
|  |  |  | **Q** |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  | **P** |  |
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|  |  |  |  |  |  |  |  |  |  |  | **B** |  |  |
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|  |  |  |  |  | **A** |  |  |  |  |  |  |  |  |
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1. Find the gravitational field vector at the origin. Fill in this table.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **magnitude** | **trig. angle** | **x-comp** | **y-comp** |
| gA |  |  |  |  |
| gB |  |  |  |  |
|  |  | gA + gB |  |  |
|  |  |  | Magnitude | Trig Angle |
|  |  |  |  |  |

2. What is the gravitational potential at location P? What is the gravitational potential at location Q? What is the potential at the origin?

3. If I were to move 72.5 kg of mass from Q to P, how much work would I have to do?

4. If I move 72.5 kg from Q to the origin, what work do I do? Then move it from the origin to point P – How much work is that? How does the total of both moves compare to the answer in 3.?

Answers to B

1:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | m | x | y | mag | trig angle |
| A | 6.56E+12 | -2 | -5 | 15.09 | 248.20 |
| B | 4.81E+12 | 4 | 1 | 18.87 | 14.04 |
|  |  | x | y |  |  |
|  | Ea | -5.60354 | -14.009 |  |  |
|  | Eb | 18.3087 | 4.57718 |  |  |
|  |  | **12.71** | **-9.43** | **N/C** |  |
|  |  | mag | angle |  |  |
|  |  | **15.8233** | **323.412** |  |  |

2-4:

|  |  |  |
| --- | --- | --- |
| 2. Vp | -184.64 | J/kg |
| Vq | -78.78 | J/kg |
| Vo | -159.06 |  |
| 3. Wqp | -7.68E+03 | J |
| 4. Wq-o | -5.82E+03 | J |
| Wo-p | -1.85E+03 | J |
| Total | -7.68E+03 | J |

The total is the same - It doesn’t matter how you go from Q to P, the net work is the same.

**C.** General Questions - Gravity:

|  |  |
| --- | --- |
| 13 N/kg  2500 N  5250 N  9.90x106 m  24 J/kg  2.4 m  5.3x103 J  9.5 m/s  -1.2x10-7 J/kg  -2.82x106 J/kg  1.23x108 J  2.04x108 J  1.66x103 m/s  210 J  1.62 N/kg  13 km  2100 J  43 m  18 N/kg | 1. What is the gravitational field strength at the surface of a planet if 5.3 kg of mass experiences 67.2 N of downward force due to gravity? 2. What force does a 34 N/kg gravitational field exert on a 72.5 kg mass? 3. What is the force of gravity between a 674 kg object that is 7.15x106 m from earth’s center? (Earth has a mass of 5.97x1024 kg) 4. At what distance from the center of the moon is the force of gravity on a 100.0 kg mass 5.00 N? (The moon has a mass of 7.35x1022 kg) 5. What is the change in gravitational potential (in J/kg) if it takes 812 J of energy to lift a 34 kg object from the floor to a shelf? If g is 9.81 N/kg, what is the shelf height? 6. A 117 kg mass falls freely from rest through a gravitational potential difference of 45 J/kg. What potential energy in J does it turn into kinetic energy, and what is its final velocity? 7. What is the gravitational potential (in J/kg) 12 cm from the center of a 212 kg ball of lead? 8. What is the gravitational potential (in J/kg) at the surface of the moon? (The moon has a mass of 7.35x1022 kg and a radius of 1.737x106 m) 9. The earth has a mass of 5.97x1024 kg, and a radius of 6.38x106 m. What work does it take to bring a 5.00 kg object from the surface of the earth to an elevation of 4.15x106 m above the earth’s surface? How does that compare to the same calculation using ΔEp =mgΔh, where we assume g is a uniform 9.81 N/kg 10. An object approaches the moon. ( Moon’s mass: 7.35 x 1022 kg, radius: 1.737 x 106 m) If the object is going 1210 m/s when it is 2.26 x 106 m from the moon’s center, what is its speed when it strikes the surface? 11. How much work does it take to move two 4.5x106 kg spheres whose centers are separated by 3.5 m initially, so that their centers are separated by 7.8 m? 12. What is the gravitational field strength on the surface of the moon with a radius of 1.737x106 m, and a mass of 7.35x1022 kg? 13. What is the radius of a neutron star with a gravitational field strength of 3.4x1013 N/kg, and a mass of 8.13x1031 kg? 14. The top of a hill is 420 J/kg higher in gravitational potential than the bottom. What work does it take to lift a 5.0 kg object from the bottom of the hill to the top? If the g is 9.81 N/kg, how high is the hill? 15. On the planet Zot, a hill 23.1 m high represents a potential change of 416 J/kg of gravitational potential. What is the g on planet Zot? |

**D.** General Questions - Electricity:

|  |  |
| --- | --- |
| 7.8x103 N/C  8.3x10-16 N  19.6 N rt  94.8 km  5.4x107 V  3.84x10-18 J  6.78x104 m/s  2.5x104 V  39 cm  2.77 J  26.4 m/s  18.0 m/s  -0.029 J  1.0x105 N/C rt  -3.34x10-8 C  1380 J  4.14 cm  2.3x105 N/C | 1. What is the electrical field strength near a charged object if 2.3 μC of charge experiences .018 N of upward force due to the electric field? 2. What force does a 5200 N/C electrical field exert on a proton? 3. A 34.8 μC charge is 45.0 cm to the right of a -12.7 μC charge. What is the force on the leftmost charge? 4. How far apart do two 1.00 C charges need to be so that they experience a force of repulsion of 1.00 N 5. What is the change in electrical potential if it takes 812 J of energy to move a 15 μC charge from point A to point B? 6. A proton accelerates from rest through an electric potential of 24.0 V. What is its change in potential energy, and what is its final velocity? 7. What is the electrical potential 7.8 cm from the center of a 0.215 μC charge? 8. A sphere has a 2.1 μC charge spread evenly over its surface. What is the sphere’s radius if the electric potential on the surface is 48,000 V? 9. A 25.1 μC charge is 67.0 cm to the right of a 16.8 μC charge. What work would it take to bring them closer so that they are separated by only 45.0 cm? If they each have a mass of 12.1 grams, what is their speed when they are very far away, if they are released from a distance of 45.0 cm? (Neglect other forces) 10. Three 115 gram 25.0 μC charges occupy the corners of an equilateral triangle 30.0 cm on a side. If the charges are released simultaneously, what is their speed when they are very far away, assuming no other force acts on them? (Bring the charges in from infinity one by one, add the work together…) 11. How much work does it take to move two 4.5 μC spheres whose centers are separated by 3.5 m initially, so that their centers are separated by 7.8 m? 12. What is the electric field 3.5 cm to the right of a 0.0137 μC charge? 13. There is a 12,350 N/C upward electric field 15.6 cm below what charge? 14. Two parallel plated have a potential of 600. Volts across them. What work does it take to move 2.3 C of charge from one plate to the other? If the plates have an electric field intensity of 14,500 V/M between them, what is their separation? 15. Two parallel plates are separated by 3.1 mm, and have 710. Volts of electric potential across them. What is the electrical field intensity between the plates? |