Physics Selected Questions

Student Activities Conferences 2018-2019

You discover a star cluster that contains a large number of O and B class stars. You also notice that all of the stars in the cluster are metal-rich. What can you conclude about this cluster?

A) This is a young cluster that formed very recently.
B) This is an old cluster from the earliest period of the universe.
C) The stars in the cluster are unlikely to have any planets.
D) There are probably large numbers of white dwarfs in the cluster.
E) There should be no M or K class stars in the cluster.

A race car is moving at 130.0m/s when a caution flag appears. The car slows uniformly to 25.0m/s in a time of 12.5sec. How far does the car travel while it is slowing down?

A) 313m
B) 656m
C) 813m
D) 970m
E) 1625m

The car is accelerating during the time it is slowing down, so let's first find that acceleration:

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_0}{\Delta t} = \frac{25.0 - 130.0}{12.5} = -8.40 \text{ m/s}^2.$$

Now we can use a kinematic equation to find the distance travelled:

$$x = x_0 + v_0 t + \frac{1}{2} a t^2 = 0 + (130)(12.5) + (0.5)(-8.40)(12.5)^2 = 970\text{m}.$$

A 100.0kg crate of rocks is dragged across the floor by a horizontal force of 500.0N. The coefficient of friction between the floor and the crate is 0.38. What is the acceleration of the crate?

A) $1.28\ m/s^2$
B) $1.96\ m/s^2$
C) $3.72\ m/s^2$
D) $4.62\ m/s^2$
E) $5.00\ m/s^2$

The force diagram for this problem would have four forces on it: an applied horizontal force (F, to the right), a horizontal frictional force (F_f, to the left), the weight of the box (mg, directed downward), and the normal force (F_N, directed upward).

Since the box doesn't move vertically, we know that the vertical forces must be balanced.

$F_N = mg = (100)(9.8) = 980\ N.$

Also, the frictional force depends on the normal force:

$F_f = \mu F_N = (0.38)(980) = 372.4\ N.$

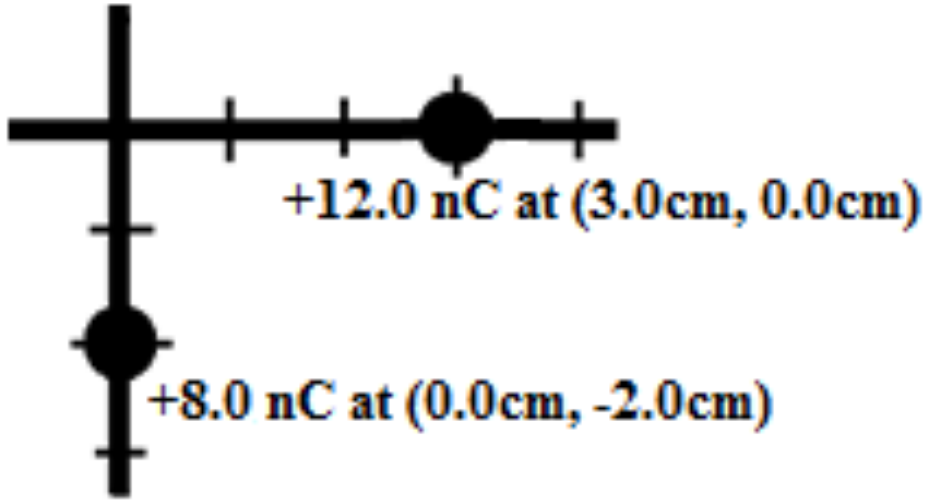
Thus, the total horizontal force is

$\sum F_x = F - F_f = 500 - 372.4 = 127.6\ N = ma = (100)a.$

Thus, the acceleration of the crate is $a = \frac{127.6}{100} = 1.28$ m/s^2.

Calculate the electric potential at the origin $(0, 0)$ due to the charges shown.

A) 0.0 V
B) 1990 V
C) 2990 V
D) 3600 V
E) 7190 V



The electric potential due to the first charge is:

$$V_1 = \frac{kQ_1}{r_1} = \frac{(8.99 \times 10^9)(12 \times 10^{-9})}{(0.03)} = 3596\,V.$$

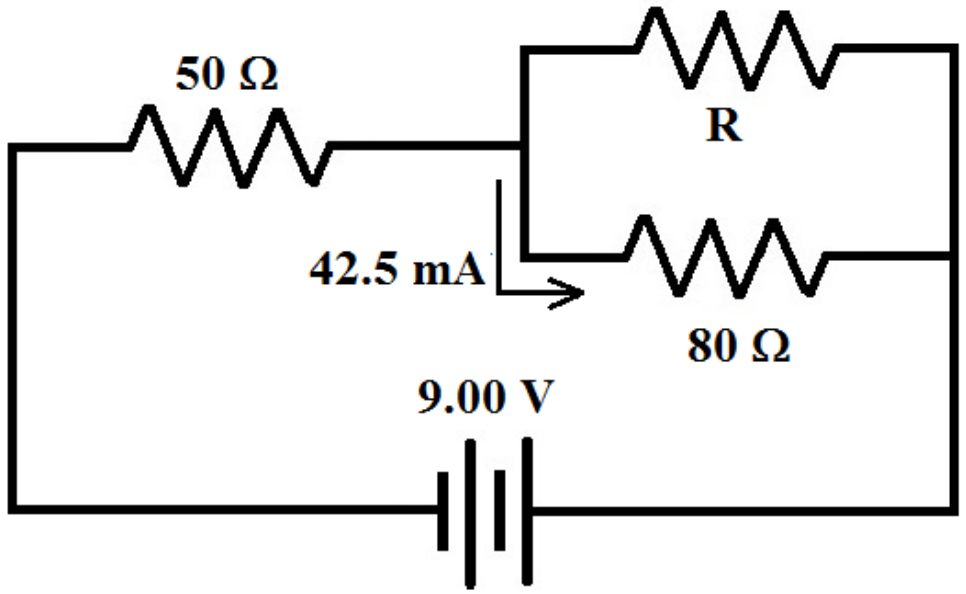
The electric potential due to the second charge is also

$$V_2 = \frac{kQ_2}{r_2} = \frac{(8.99 \times 10^9)(8.0 \times 10^{-9})}{(0.02)} = 3596\,V.$$

The total electric potential at the origin is just the sum of the potentials of the individual charges: $V = 3596 + 3596 = 7192\,V \approx 7190\,V$.

Given the current and voltage shown in this circuit, determine the unknown resistance, R.

A) 49 Ω
B) 80 Ω
C) 130 Ω
D) 160 Ω
E) 210 Ω



Since we have the current in the 80 Ω resistor, we can get the voltage across that resistor: $V_{80} = IR = (0.0425)(80) = 3.40\ V$.

Elements in parallel have the same voltage across them, so we know the voltage across the unknown resistor R is also 3.40V.

The voltage across a parallel group is the same as the voltage across any element in the parallel group; thus, the voltage of the entire parallel group is $V_p = 3.40\ V$.

The battery provides the circuit with 9.00 V, so the remaining voltage must be across the 50 Ω resistor: $V_{50} = 9.00 - 3.40 = 5.60\ V$.

This allows us to calculate the current through the 50 Ω resistor: $I_{50} = \frac{V_{50}}{R} = \frac{5.60}{50} = 0.112\ A$. This is the total current flowing to the parallel group.

Only 0.0425 A flows down through the 80 Ω resistor, so the remaining current must flow up through the unknown resistor: $I_R = 0.112 - 0.0425 = 0.0695\ A$.

Finally, we can get the value of the unknown resistor, since we know both the voltage across it and the current through it: $R = \frac{V}{I} = \frac{3.40}{0.0695} = 49\ \Omega$.

A spherical polished brass doorknob acts like a convex mirror. If you place your hand 5.00 cm from the doorknob, by what factor is the reflection of your hand magnified? The diameter of the doorknob is 8.00 cm

A) 0.29
B) 0.44
C) 0.62
D) 0.67
E) 4.0

Since the doorknob is a spherical convex mirror, we know that the focal length will be negative.

Also, since the diameter is 8.00 cm, then the radius will be 4.00 cm. The focal length is given by

$f = \frac{R}{2} = \frac{-4.00}{2} = -2.00\ cm.$

Now we can find the image location: $\frac{1}{p} + \frac{1}{q} = \frac{1}{f} = \frac{1}{5.00} + \frac{1}{q} = \frac{1}{-2.00}$.

This gives an image location of $q = -1.43\ cm$.

Then the magnification is $M = -\frac{q}{p} = -\frac{-1.43}{5} = 0.29$.

A starship passes by a moon base at a relative speed of 0.97c. The starship appears to be only 220m long to people at the base. How long is the starship as measured by people on the starship?

A) 3720m
B) 1270m
C) 905m
D) 427m
E) 227m

This is a special relativity length contraction problem. Moving objects, as seen by stationary observers, are contracted in length.

In this problem, we are given the contracted length: 220m. We also have the speed of the starship, so we can go to the length contraction formula to find the "original" length of the starship:

$$L' = L_0\sqrt{1-\frac{v^2}{c^2}} = L_0\sqrt{1-\frac{(0.97c)^2}{c^2}} = L_0\sqrt{1-0.941} = 0.243L_0$$

This gives $L' = 220 = 0.243L_0$, or $L_0 = \frac{220}{0.243} = 905\text{m}$.

You plot the position of a toy car at regular intervals of time as it travels across the floor, and collect the following data:

Given this data, what is the toy car doing?

A) the toy car is stationary.

B) the toy car is moving with a constant positive speed.

C) the toy car is moving with a constant negative speed.

D) the toy car is accelerating with a positive acceleration.

E) the toy car is accelerating with a negative acceleration.