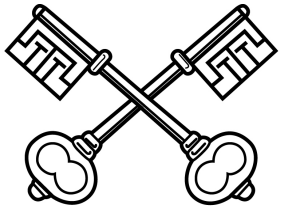

RADLEY

Warm-up problems

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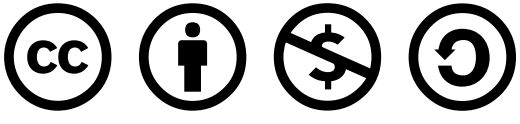

Warm up problems: don't forget ESAU!

1. If an object of mass 5 kg experiences a force of 3 N, what is its acceleration?
2. A car's speed increases from 25 m/s to 60 m/s in 5 s. What is its acceleration?
3. If the mass of the car is 1200 kg, what is its final kinetic energy at 60 m/s?
4. How many protons, neutrons and electrons are there in a $^{108}\mathrm{Ag}^{+}$ ion?
5. If a 9 V battery is connected to a circuit of resistance 45 Ω, what current flows?

Solutions (1)

1 $F = ma$, $a = \dfrac{F}{m} = \dfrac{3\,\text{N}}{5\,\text{kg}} = 0.6\,\text{m/s}^2$

2 $a = \dfrac{\Delta v}{t} = \dfrac{60\,\text{m/s} - 25\,\text{m/s}}{5\,\text{s}} = \dfrac{35\,\text{m/s}}{5\,\text{s}} = 7\,\text{m/s}^2$

3 $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 1200\,\text{kg} \times (60\,\text{m/s})^2 = 2\,160\,000\,\text{J}$

4 47 protons, 61 neutrons and 46 electrons

5 $V = IR$, $I = \dfrac{V}{R} = \dfrac{9\,\text{V}}{45\,\Omega} = 0.2\,\text{A}$

Warm up problems (2): use ESAU!

1. If a charge of 2 C flows through an ammeter in 5 s, what will the current read?
2. A car starting at a speed of 5 m/s accelerates at $3\,\mathrm{m/s^2}$ for 12 s. What is its final speed?
3. If a battery supplies a current of 0.8 A for 28 s, what charge has flowed?
4. A pure gold ring has mass 15 g and gold has density $19.6\,\mathrm{g/cm^3}$. What is its volume?
5. If a lightbulb has a current of 1.2 A flowing through it, how long will it take for 90 C of charge to flow through it?

Solutions (2)

1 $I = \dfrac{Q}{t} = \dfrac{2\,\mathrm{C}}{5\,\mathrm{s}} = 0.4\,\mathrm{A}$

2 $a = \dfrac{\Delta v}{t}$, $\Delta v = at = 3\,\mathrm{m/s^2} \times 12\,\mathrm{s} = 36\,\mathrm{m/s}$

Starting speed $= 5\,\mathrm{m/s}$, so final speed $= 41\,\mathrm{m/s}$.

3 $Q = It = 0.8\,\mathrm{s} \times 28\,\mathrm{s} = 22.4\,\mathrm{C}$

4 $\rho = \dfrac{m}{V}$, $V = \dfrac{m}{\rho} = \dfrac{15\,\mathrm{g}}{19.6\,\mathrm{g/cm^3}} = 0.77\,\mathrm{cm^3}$

5 $Q = It$, $t = \dfrac{Q}{I} = \dfrac{90\,\mathrm{C}}{1.2\,\mathrm{A}} = 75\,\mathrm{s}$

Warm up problems (3): use ESAU!

1. A car drives 82.0 miles in 3 h 46 min. What is its average speed
   (a) in mph?
   (b) in m/s? [Hint: 1 mile = 1600 m]
2. A Nissan LEAF accelerates to 27.5 m/s from rest in 11.5 s. What is its acceleration?
3. An electric car charging point supplies a voltage of 394 V and a current of 104 A.
   (a) What is the resistance of the car charging (connected to the charging point)?
   (b) The car is connected for 29 min. How much charge has flowed?

Solutions (3)

1 (a) $v = \dfrac{d}{t} = \dfrac{82.0\,\text{mile}}{3\,\text{h} + \frac{46}{60}\,\text{h}} = 21.8\,\text{mph}$

(b) $21.8\,\dfrac{\text{mile}}{\text{h}} \times \dfrac{1600\,\text{m}}{\text{mile}} \times \dfrac{1\,\text{h}}{60\,\text{min}} \times \dfrac{1\,\text{min}}{60\,\text{s}} = 9.7\,\text{m/s}$

2 $a = \dfrac{\Delta v}{t} = \dfrac{27.5\,\text{m/s}}{11.5\,\text{s}} = 2.39\,\text{m/s}^2$

3 (a) $V = IR,\ R = \dfrac{V}{I} = \dfrac{394\,\text{V}}{104\,\text{A}} = 3.79\,\Omega$

(b) $Q = It = 29\,\text{min} \times \dfrac{60\,\text{s}}{\text{min}} \times 104\,\text{A} = 181\,000\,\text{C}$

Warm up problems (4): use ESAU!

1. A solar panel generates 300 J of electrical energy for every 1400 J of light energy. What is its efficiency?
2. A flashlamp bulb operates at a voltage of 2.5 V and a current of 0.3 A. What is its resistance?
3. A Nissan LEAF has mass 1557 kg. If it accelerates at $2.3\,\mathrm{m/s^2}$, what is the unbalanced force on it?
4. A man has mass of 77.5 kg. What is his weight on the Moon (gravitational field strength $= 1.63\,\mathrm{N/kg}$)?
5. A laser beam entering water (refractive index $= 1.33$) refracts at 12° to the normal. What was the angle of incidence?

Solutions (4)

1 $\text{efficiency} = \dfrac{\text{useful energy out}}{\text{total energy in}} \times 100\% =$

$$\frac{300\,\text{J}}{1400\,\text{J}} \times 100\% = 21.4\%$$

2 $V = IR$, $R = \dfrac{V}{I} = \dfrac{2.5\,\text{V}}{0.3\,\text{A}} = 8.33\,\Omega$

3 $F = ma = 1557\,\text{kg} \times 2.3\,\text{m/s}^2 = 3580\,\text{N}$

4 $W = mg = 77.5\,\text{kg} \times 1.63\,\text{N/kg}$

5 $n = \dfrac{\sin(\text{big})}{\sin(\text{small})}$,

$\sin(\text{big}) = n\sin(\text{small}) = 1.33 \times \sin(12^\circ) = 0.27652\ldots$

$\text{big} = \sin^{-1}(0.27652\ldots) = 16.1^\circ$

Warm up problems (5): use ESAU!

1. A light beam hits glass (refractive index $= 1.52$) at an angle of incidence of 48°. What is the angle of refraction?
2. A man pushed a car 8 m, doing 1800 J of work in the process. What force did he push the car with?
3. 78 C of charge flow through an ammeter in 32.5 s. What current does the ammeter read?
4. A marble of mass 25 g rolls at 0.6 m/s along a track. What is its kinetic energy?
5. 45 C of electrical charge leave a 9 V battery. How much energy does this charge carry?

Solutions (5)

1 $n = \dfrac{\sin(\text{big})}{\sin(\text{small})}$,

$$\sin(\text{small}) = \frac{\sin(\text{big})}{n} = \frac{\sin(48^\circ)}{1.52} = 0.488911\ldots$$

$$\text{small} = \sin^{-1}(0.488911\ldots) = 29.3^\circ$$

2 $W = Fd$, $F = \dfrac{W}{d} = \dfrac{1800\,\text{J}}{8\,\text{m}} = 225\,\text{N}$

3 $Q = It$, $I = \dfrac{Q}{t} = \dfrac{78\,\text{C}}{32.5\,\text{s}} = 2.4\,\text{A}$

4 $\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.025\,\text{kg} \times (0.6\,\text{m/s})^2 = 4.5 \times 10^{-3}\,\text{J}$

5 $E = QV = 45\,\text{C} \times 9\,\text{V} = 405\,\text{J}$

Warm up problems (6): use ESAU!

1. What is the mass of an object if a force of 72 N makes it accelerate at $8\,\mathrm{m/s^2}$?
2. How far under water (density $1000\,\mathrm{kg/m^3}$) do you have to go for the pressure to increase by $9 \times 10^5\,\mathrm{Pa}$?
3. If light refracts into diamond (refractive index $= 2.42$) at 12° to the normal, what was the angle of incidence?
4. How far up a staircase does a man of mass 85 kg need to go to gain 10 000 J of GPE?
5. What is the *critical angle* for diamond?

Solutions (6)

1 $F = ma$, $m = \dfrac{m}{a} = \dfrac{72\,\text{N}}{8\,\text{m/s}^2} = 9\,\text{kg}$

2 $P = \rho g h$, $h = \dfrac{P}{\rho g} = \dfrac{9 \times 10^5\,\text{Pa}}{1000\,\text{kg/m}^3 \times 10\,\text{N/kg}} = 90\,\text{m}$

3 $n = \dfrac{\sin(\text{big})}{\sin(\text{small})}$,

$\sin(\text{big}) = n \sin(\text{small}) = 2.42 \times \sin(12^\circ) = 0.5031\ldots$

$\text{big} = \sin^{-1}(0.5031\ldots) = 30.2^\circ$

4 $\text{GPE} = mgh$, $h = \dfrac{\text{GPE}}{mg} = \dfrac{10\,000\,\text{J}}{85\,\text{kg} \times 10\,\text{N/kg}} = 11.8\,\text{m}$

5 $\sin c = \dfrac{1}{n}$, $c = \sin^{-}1\left(\dfrac{1}{2.42}\right) = 24.4^\circ$

Warm up problems (7): use ESAU!

1. What is the mass of an object which weighs 80 N on Jupiter (where the gravitational field strength is 25 N/kg)?
2. What is the kinetic energy of a tennis ball of mass 58 g and served at 64 m/s?
3. How long will it take for a long distance runner at 2.4 m/s to cover 180 km?
4. How much work does a horse pulling a cart with a force of 4100 N for a distance of 15 m do?
5. What was the starting speed if a car accelerating at $3\,\mathrm{m/s^2}$ for 4 s reaches a speed of 28 m/s?

Solutions (7)

1 $W = mg$, $m = \dfrac{W}{g} = \dfrac{80\,\text{N}}{25\,\text{N/kg}} = 3.2\,\text{g}$

2 $\text{KE} = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.058\,\text{kg} \times (64\,\text{m/s})^2 = 119\,\text{J}$

3 $v = \dfrac{d}{t}$, $t = \dfrac{d}{v} = \dfrac{180\,000\,\text{m}}{2.4\,\text{m/s}} = 75\,000\,\text{s} = 1250\,\text{min} =$ 20 h 50 min

4 $W = Fd = 4100\,\text{N} \times 15\,\text{m} = 61\,500\,\text{J}$

5 $a = \dfrac{\Delta v}{t}$, $\Delta v = at = 3\,\text{m/s} \times 4\,\text{s} = 12\,\text{m/s}$

Starting speed $= 28\,\text{m/s} - 12\,\text{m/s} = 16\,\text{m/s}$

Warm up problems (8): use ESAU!

1. What is the mass of a piece of lead of volume $8.3\,\mathrm{cm}^3$ annd density $11.3\,\mathrm{g/cm}^3$?
2. How much energy dissipates in a lightbulb with potential difference $3.5\,\mathrm{V}$ across it if $12\,\mathrm{C}$ flow through?
3. What is the current in the bulb it has resistance $15\,\Omega$?
4. If the critical angle of perspex is 42°, what is the refractive index?
5. How much GPE does a cannonball of mass $5\,\mathrm{kg}$ gain ascending to the top floor of the Eiffel tower, $276\,\mathrm{m}$ above the ground?

Solutions (8)

1 $\rho = \dfrac{m}{V}$, $m = \rho V = 11.3\,\text{g/cm}^3 \times 8.3\,\text{cm}^3 = 93.8\,\text{g}$

2 $E = QV = 12\,\text{C} \times 3.5\,\text{V} = 42\,\text{J}$

3 $I = \dfrac{V}{R} = \dfrac{3.5\,\text{V}}{15\,\Omega} = 0.23\,\text{A}$

4 $\sin c = \dfrac{1}{n}$, $n = \dfrac{1}{\sin c} = \dfrac{1}{\sin(42^\circ)} = 1.49$

5 $\text{GPE} = mgh = 5\,\text{kg} \times 10\,\text{N/kg} = 276\,\text{m} = 13\,800\,\text{J}$

Warm up problems (9): use ESAU!

1. How much light energy comes from a 78% efficient lightbulb if 350 J of electrical energy is transferred to it?
2. What is the acceleration if a 2400 kg truck experiences an unbalanced force of 1800 N?
3. What is the voltage across an LED if its resistance is 6.5 Ω whan a current of 200 mA flows?
4. How far does light travel in 8 minutes? What is the astronomical significance of this distance?
5. How much energy is transferred if 2.6 C of charge flows from a 1.5 V battery?

Solutions (9)

1 $\text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}}$,

$$\text{useful energy} = 350\,\text{J} \times \frac{78\%}{100\%} = 273\,\text{J}$$

2 $a = \dfrac{F}{m} = \dfrac{1800\,\text{N}}{2400\,\text{kg}} = 0.75\,\text{m/s}^2$

3 $V = IR = 200 \times 10^{-3}\,\text{A} \times 6.5\,\Omega = 1.3\,\text{V}$

4 $d = s \times t = 3 \times 10^8\,\text{m/s} \times (8 \times 60\,\text{s}) = 1.44 \times 10^{11}\,\text{m}$

5 $E = QV = 2.6\,\text{C} \times 1.5\,\text{V} = 3.9\,\text{J}$