Solution Authoring Guidelines

Version 9.4
September 2016

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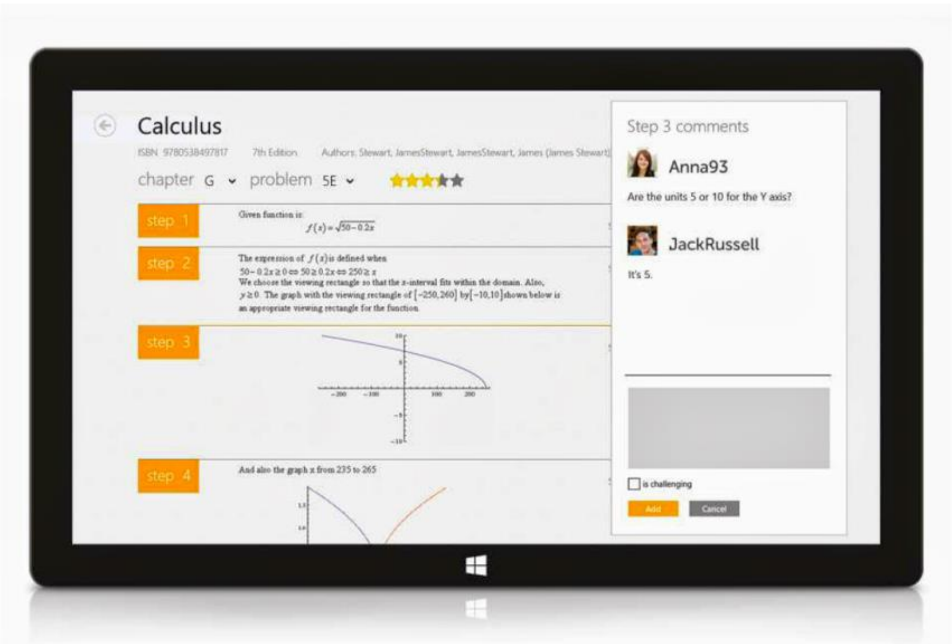

Subject-specific Guidelines- Physics

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List of changes made over Version 9.1

- Information regarding tables in P1. Content has been removed .... Page no. 3
- Second bullet point in D. Graphs has been removed .... Page no. 6

List of changes made over Version 9.2

- Last line has been added to the second paragraph in P1. Content (A)............... Page no. 3
- Modified the content in the C. Diagrams...Page no.4

List of changes made over Version 9.3

- Two images under 'Vector notation'(P1.Content) has been modified.................Page no.4

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P1. Content:

A. Text/Explanation:

"Conceptual" questions: Solve each question based on the underlying concept(s) provided in the chapter. Solutions may often have multiple steps.

"Check Your Understanding" questions: The solution should be in a step-by-step manner and should neither be too brief nor too lengthy.

Note: Single step solutions are not allowed. Recollect that steps are separated by delimiters.

i. Units Conversion:

Unit conversions should be explicit to avoid mistakes.

WRONG METHOD:

$$\begin{aligned}\Delta V &= 40.0 \text{ kV} \\ &= 40.0\times 10^{3} \text{ V}\end{aligned}$$

CORRECT METHOD:

$$\begin{aligned}\Delta V &= 40.0 \text{ kV} \\ &= (40.0 \text{ kV})\left(\frac{10^{3} \text{ V}}{1 \text{ kV}}\right) \\ &= 40.0\times 10^{3} \text{ V}\end{aligned}$$

ii. Units Representation:

Use mid-dot instead of dot between units.

WRONG:

Impulse, $J = 23.0 \text{ N.m}$

CORRECT:

Impulse, $J = 23.0 \text{ N}\cdot\text{m}$

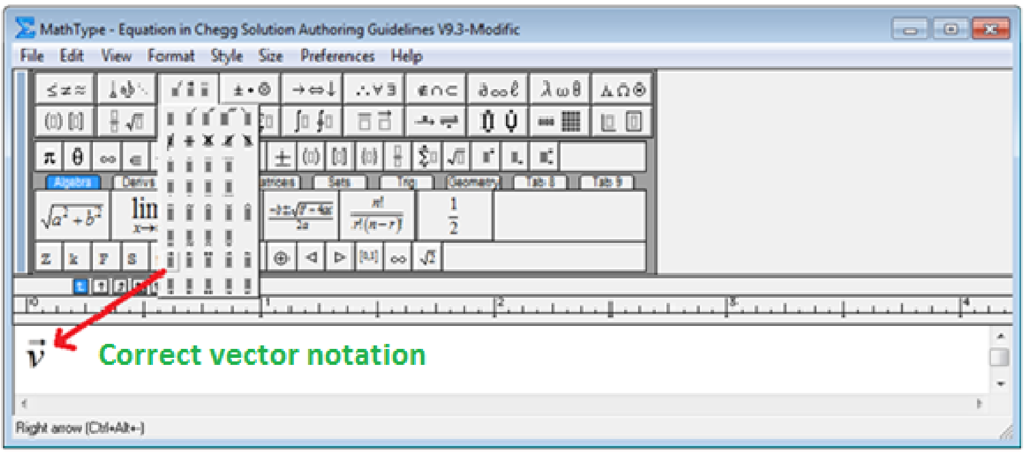
(Note the type of the dot used between N and m)

iii. Vector notation:

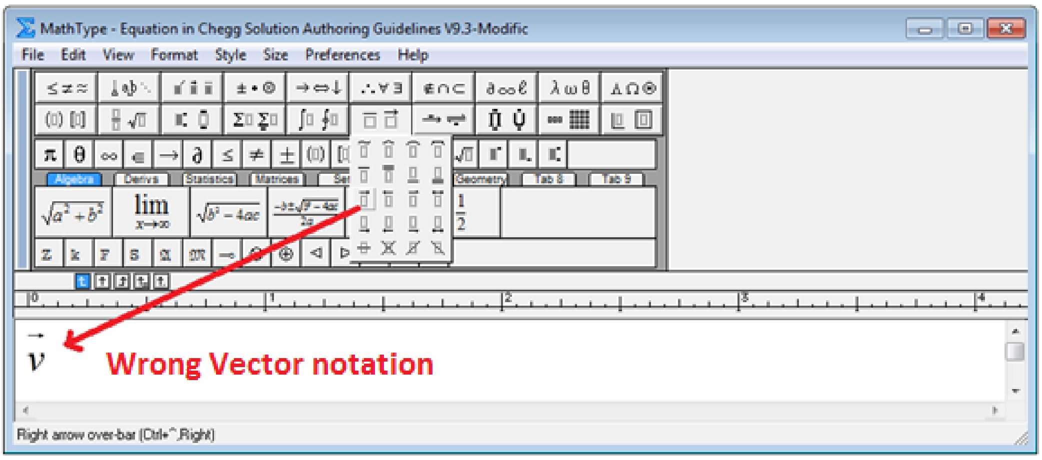
The vector quantities must be represented by a variable with bar/arrow symbol above it.

Example: $\bar{A}$ or $\vec{A}$ (follow either one according to textbook notation)

The following screenshot shows the **correct** representation of a vector variable in MathType:



The following screenshot shows the **wrong** representation of the vector variable in MathType:



B. Equations:

i. Substitution in an equation:

Specify units of all quantities during substitution and simplification of every step.

WRONG METHOD:

The formula to find the shortest wavelength of the radiation is,

$$\begin{aligned}\lambda_{\min} &= \frac{hc}{e\Delta V} \\ &= \frac{(6.63\times10^{-34})(3.0\times10^{8})}{(1.60\times10^{-19})(40.0\times10^{3})} \\ &= 3.1078\times10^{-11} \\ &= 3.11\times10^{-2}\ \text{nm}\end{aligned}$$

CORRECT METHOD:

The formula to find the shortest wavelength of the radiation is,

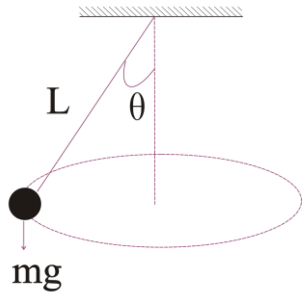
$$\begin{aligned}\lambda_{\min} &= \frac{hc}{e\Delta V} \\ &= \frac{(6.63\times10^{-34}\ \text{J}\cdot\text{s})(3.0\times10^{8}\ \text{m/s})}{(1.60\times10^{-19}\ \text{C})(40.0\times10^{3}\ \text{V})} \\ &= 3.1078\times10^{-11}\ \text{m} \\ &= (3.11\times10^{-11}\ \text{m})\left(\frac{1\ \text{nm}}{10^{-9}\ \text{m}}\right) \\ &= 3.11\times10^{-2}\ \text{nm}\end{aligned}$$

Therefore, the shortest wavelength of radiation is $\boxed{3.11\times10^{-2}\ \text{nm}}$.

C. Drawing diagrams:

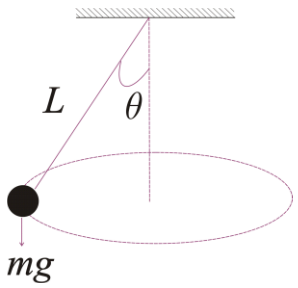
The variables labeled in diagrams should be in italics.

WRONG:



In the above diagram, the variables are not in italics.

CORRECT:



D. Graphs:

- The scale chosen for the graph must be indicated at top right side corner of the graph.

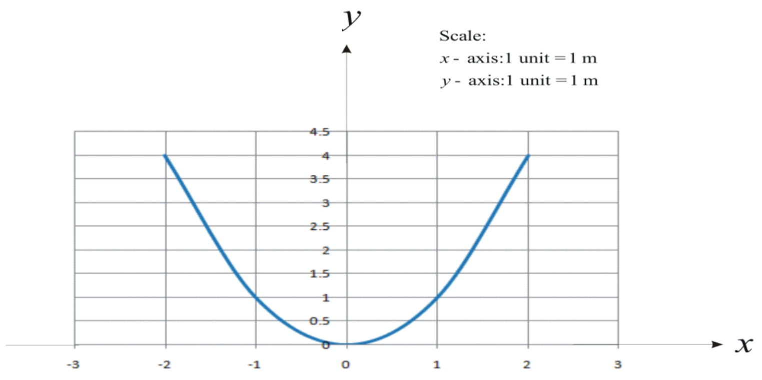
Example:

When an object is projected at certain angle with the horizontal, the displacement in the vertical direction $y(x)$ is related to the displacement in the horizontal direction (x) by the relation $y(x) = x^2$.

Tabular form of *y* versus *x*:

$x(\text{m})$	$y(\text{m})$
-2	4
-1	1
0	0
1	1
2	4

Plot of the graph:



P2. Special points/ others:

i. Significant figures/digits:

The final and sometimes the intermediate answers of a solution must be rounded off based on the significant figures of the quantities given in the question. Significant figures indicate the degree of accuracy of measurement of the quantities involved.

Note: Rounding should be done only on intermediate or final answers/results. Throughout the solution, all calculations should be done with unrounded numbers only.

Rules to find the significant figures:

- All non-zero digits are significant.
  Example: 125 has 3 significant figures.

- Zeros between non-zeros are significant.
  Example: 12004 has 5 significant figures.

- Zeros to the left of the first non-zero number are not significant.
  Example: 0.0012 has only 2 significant figures.

- Zeros to the right of a decimal point are significant.
  Example: 12.40 has 4 significant figures.

- Zeros that "hold places" are not significant.
  Example: 123,000 has only 3 significant figures.

ii. Rules for Rounding off the final/intermediate answer:

- Check the quantities used in the calculations and pick the least number of significant digits among them
- Round off the final answer to the least number of digits chosen
- If the first digit to be dropped is less than 5, then the last significant digit would remain unchanged.
- If the first digit to be dropped is greater than 5 then the last significant digit should be increased by 1.

Examples:

1) Round 7.4882 to three significant digits

= 7.49

2) Round 7.998 to three significant digits

= 8.00

- If the first digit to be dropped is “5” (which is not followed by any other digits or followed only by *zeros*) and the last significant digit is *even*, then the last significant digit would remain unchanged.

  Examples:

  1) Round 7.8500 to two significant digits

  Answer = 7.8

  2) Round 8.465 to three significant digits

  Answer = 8.46

- If the first digit to be dropped is “5” (which is not followed by any other digits or followed only by *zeros*) and the last significant digit is *odd*, then the last significant digit would be increased by 1.
- Examples: 1) Round 7.775000 to three significant digits

  = 7.78

  2) Round 7.995 to three significant digits

  = 8.00

- If the first digit to be dropped is “5” (which is followed by any *non-zero* digit) then the last significant digit would be increased by 1

  Examples:

  1) Round 7.8501 to two significant digits

  = 7.9

  2) Round 8.4652007 to three significant digits

  = 8.47

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Example Solutions - Physics

List of changes made over Version 9.1

- Modified some content in example 1……………………………………………………………Page no. 10
- Modified MCQ example as per guidelines…………………………………………………….Page no. 12

List of changes made over Version 9.2

- Physics example 2 MCQ example changed as per latest guidelines…………………Page no. 12
- Physics example 3 VSAQ example has been added………………………………………..Page no. 13
- Physics example 4 Fill in the blank has been added…..……………………………………Page no. 13
- Physics example 5 True or False has been added…………………………………………..Page no. 14

List of changes made over Version 9.3

- Only tab spaces removed for equations.

Physics Example 1: Calculation based

Question:

The heart produces a weak magnetic field that can be used to diagnose certain heart problems. It is a dipole field produced by a current loop in the outer layers of the heart.

(a) The field at the center of the heart is 60 pT. What current must circulate around a 16.0 cm diameter loop about the size of a human heart to produce this field?

(b) What is the magnitude of the heart's magnetic dipole moment?

Solution:

(a)

The expression to find the magnetic field *B* at the center of a loop with radius *R* is,

$$B = \frac{\mu_0 I}{2R}$$

Here, μ_0 is the permeability of free space and *I* is the current required to produce the magnetic field.

Rewrite the equation in terms of current *I*.

$$I = \frac{2BR}{\mu_0}$$

Since radius *R* is equal to half of the diameter *d*, substitute $\frac{d}{2}$ for R.

$$\begin{aligned} I &= \frac{2B\left(\frac{d}{2}\right)}{\mu_0} \\ &= \frac{Bd}{\mu_0} \end{aligned}$$

Convert the magnetic field from Pico tesla to tesla.

$$\begin{aligned} B &= (60 \text{ pT})\left(\frac{1\times10^{-12} \text{ T}}{1 \text{ pT}}\right) \\ &= 60\times10^{-12} \text{ T} \end{aligned}$$

Convert the diameter from cm to m.

$$\begin{aligned} d &= (16.0 \text{ cm})\left(\frac{1 \text{ m}}{100 \text{ cm}}\right) \\ &= 0.16 \text{ m} \end{aligned}$$

Solve for current *I*.

$$I = \frac{Bd}{\mu_0}$$

Substitute 60×10^{-12} T for *B*, $4\pi \times 10^{-7}$ T·m/A for μ_0, and 0.16 m for *d*.

$$I = \frac{\left(60 \times 10^{-12}\ \text{T}\right)\left(0.16\ \text{m}\right)}{4\pi \times 10^{-7}\ \text{Tm/A}}$$
$$= 7.64 \times 10^{-6}\ \text{A}$$

Thus, the current required to produce a 60 pT field is $\boxed{7.64 \times 10^{-6}\ \text{A}}$.

(b)

Determine the magnitude of the heart's magnetic dipole moment.

The magnitude of the magnetic dipole moment $\vec{\mu}$ is the product of the current in the loop *I* and the area *A* of the loop.

$$|\vec{\mu}| = IA$$

Since area of the loop is equivalent to the area of a circle, the equation for the area of the loop is,

$$A = \frac{\pi R^2}{2}$$

Substitute $\frac{d}{2}$ for R.

$$A = \frac{\pi d^2}{4}$$

Now, calculate the magnitude of the heart's magnetic dipole moment using the formula,

$$\vec{\mu} = I\left(\frac{\pi d^2}{4}\right)$$

Substitute 7.64×10^{-6} A for *I* and 0.16 m for *d*.

$$|\vec{\mu}| = \frac{\pi\left(7.64 \times 10^{-6}\ \text{A}\right)\left(0.16\ \text{m}\right)^2}{4}$$
$$= 1.54 \times 10^{-7}\ \text{A}\cdot\text{m}^2$$

Thus, the magnitude of the heart's magnetic dipole moment is $\boxed{1.54 \times 10^{-7}\ \text{A}\cdot\text{m}^2}$.

Physics Example 2: Multiple choice type

Question

A change in which of the following effects the weight of an object?

(a) Momentum
(b) acceleration due to gravity
(c) unbalanced force
(d) a change in velocity

Answer:

The momentum of the object is the product of mass and velocity, whereas, the weight of an object is the product of mass and acceleration due to gravity. The change in momentum accelerates the object but doesn't affect the weight. Hence, the weight of the object is independent of momentum.

Thus, option (a) is not correct.

When an object is acted upon by an unbalanced force, the object accelerates or changes its direction of motion. The body moves in the direction of net force, which doesn't affect the weight. So, the weight of the object does not change with its acceleration.

Thus, option (c) is not correct.

The weight of the object is independent of the change in velocity.

Thus, option (d) is not correct.

The weight of an object is the product of mass and acceleration due to gravity. The amount of matter in the object is the mass, which cannot change from position to position. The value of the acceleration due to gravity has different values in different locations. So, the change in acceleration due to gravity will affect the weight of object.

Therefore, the correct option is $\boxed{(\text{b})}$.

Physics Example 3: Very Short Answer Type

Question

Which is larger, a liter or a quart?

Answer:

Liter: The volume of one kilogram water under standard conditions is named as liter.

Quart: It is a unit of capacity of liquid. The quart is equal to 946 mL.

One liter is equal to 1000 mL, where as one quart is equal to 946 mL. Therefore, **the liter is a larger unit than quart.**

Physics Example 4: Fill in the blank type

Question

Neglecting the air resistance, a horizontally thrown object and an object dropped vertically from same height fall with the same constant _______?

Answer

Assume that the air resistance is ignored.

When an object is thrown horizontally from a certain height, the acceleration of the object along the horizontal direction is zero and the only acceleration of the object along the vertically downward direction is due to gravity.

Similarly, when another object is dropped from the same height with which the first object is dropped, the object moves with acceleration equal to the acceleration due to gravity.

Therefore, both the objects will fall with same constant acceleration called acceleration due to gravity.

Hence, the blank can be filled with **acceleration**.

Physics Example 5: True/False type

Question

True or false? Tidal forces from Jupiter heat its large moons Io and Europa, leading to extensive volcanism on Io and icy slush beneath Europa's surface.

Answer

Jupiter is a giant planet and exerts a tremendous gravitational force on its moon. The natural satellites Io and Europa of Jupiter are strongly affected by its gravity. The volcanic activity on Io is result of the gravitational pull of Jupiter and its neighboring moons.

The tidal heating is also thought to be responsible for oceans of liquid water likely to exist beneath the icy crusts of Europa. Hence, the volcanoes on Io and an icy slush beneath Europa's surface are caused due to the tidal forces of Jupiter.

Hence, the given statement is **true**.

Physics Example 6: Conceptual

Question:

How much would you weigh??

- On Venus?
- On Saturn?

Solution:

The weight of a body is the force of gravitation experienced by it. Apply Newton's law of universal gravitation formula to find the weight of a body on Venus and on Saturn.

Write the Newton's law of universal gravitation formula to find the gravitational force between two objects of masses M_1, M_2 separated by a distance *R*.

$$F_g = \frac{GM_1M_2}{R^2}$$

Here, *G* is universal gravitational constant of value $6.67 \times 10^{-11}\ \text{N} \cdot \text{m}^2/\text{kg}^2$.

Assume the mass of your body to be 70 kg.

Determine the weight of your body on Venus, by calculating the gravitational force between Venus and your body using the formula of Newton's law of universal gravitation.

Substitute $6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$ for G, 70 kg for the mass of the person M_1, 4.87×10^{24} kg for mass of Venus M_2, and 6.052×10^6 m for radius of Venus R.

$$F_g = \frac{GM_1M_2}{R^2}$$

$$F_g = \frac{\left(6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2\right)\left(70\ \text{kg}\right)\left(4.87\times10^{24}\ \text{kg}\right)}{(6.052\times10^6\ \text{m})^2}$$

$$= 621\ \text{N}$$

Thus, the weight of your body on Venus would be $\boxed{621\ \text{N}}$.

Determine the weight of your body on Saturn, by calculating the gravitational force between Saturn and your body using the Newton's law of universal gravitation formula.

Substitute $6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2$ for G, 70 kg for the mass of the person M_1, 5.68×10^{26} kg for mass of Saturn M_2, and 6.027×10^7 m for radius of Saturn R.

$$F_g = \frac{GM_1M_2}{R^2}$$

$$F_g = \frac{\left(6.67\times10^{-11}\ \text{N}\cdot\text{m}^2/\text{kg}^2\right)\left(70\ \text{kg}\right)\left(5.68\times10^{26}\ \text{kg}\right)}{(6.027\times10^7\ \text{m})^2}$$

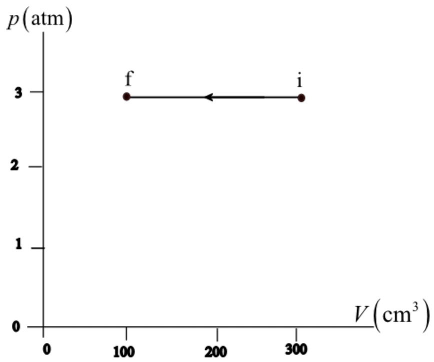
$$= 730\ \text{N}$$

Thus, the weight of your body on Saturn would be $\boxed{730\ \text{N}}$.

Physics Example 7: Graph Based

Question:

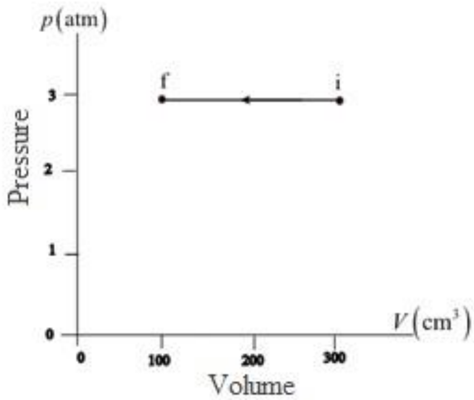
A gas with an initial temperature of 700°C undergoes the process shown in the below figure.
a. What type of process is this?
b. What is the final temperature?
c. How many moles of gas are there?



Solution:

(a)

This graph shows the values of the pressure on the *y* axis and the volume on the *x* axis,



Consider the initial values of pressure *p*, volume *V*, and temperature *T* with subscripts "i" and final values with subscript "f".
From the graph, the following values of pressure and volume of the gas are identified:

Initial volume of the gas, $V_i = 300\text{ cm}^3$

Final volume of the gas, $V_f = 100\text{ cm}^3$

Pressure of the gas, $p_i = p_f = 3\text{ atm}$

Convert the initial volume of the gas from cm^3 to m^3.

$$V_i = \left(300\ \text{cm}^3\right)\left(\frac{10^{-6}\ \text{m}^3}{1\ \text{cm}^3}\right)$$
$$= 3.0\times10^{-4}\ \text{m}^3$$

Now, convert the final volume from cm^3 to m^3.

$$V_f = \left(100\ \text{cm}^3\right)\left(\frac{10^{-6}\ \text{m}^3}{1\ \text{cm}^3}\right)$$
$$= 1.0\times10^{-4}\ \text{m}^3$$

Convert the pressure of the gas from atm to Pa.

$$p_i = \left(3\ \text{atm}\right)\left(\frac{1.013\times10^{5}\ \text{Pa}}{1\ \text{atm}}\right)$$
$$= 3.039\times10^{5}\ \text{Pa}$$

Convert the initial temperature from degree Celsius to kelvin.

$$\text{Initial temperature, } T_i = 700\ ^\circ\text{C}$$
$$= 700 + 273\ \text{K}$$
$$= 973\ \text{K}$$

Let the final temperature be T_f.

Assume the gas to be an ideal one. Use the ideal gas equation to determine the final temperature and the number of moles.

From the figure, it is clear that there is no change in the pressure. So, the pressure remains constant throughout the process. Thus, the process is Isobaric.

(b)

Use the ideal gas equation to find the final temperature of the gas.

State the expression for the ideal gas equation.

$$pV = nRT$$

Here, number of moles is n and universal gas constant is R.

Rewrite the equation as follows:

$$\frac{p_i V_i}{T_i} = \frac{p_f V_f}{T_f}$$

Since $p_i = p_f$, rewrite the equation to solve for T_f.

$$T_f = \frac{V_f T_i}{V_i}$$

Substitute $1.0\times10^{-4}\ \text{m}^3$ for V_i, $3.0\times10^{-4}\ \text{m}^3$ for V_f, and $973\ \text{K}$ for T_i.

$$\begin{aligned} T_f &= \frac{V_f T_i}{V_i} \\ &= \frac{(1.0\times10^{-4}\ \text{m}^3)(973\ \text{K})}{3.0\times10^{-4}\ \text{m}^3} \\ &= 324\ \text{K} \end{aligned}$$

Convert the final temperature from kelvin to degree Celsius.

$$\begin{aligned} T_f &= 324\ \text{K} - 273 \\ &= 51^\circ\text{C} \end{aligned}$$

Thus, the final temperature of the gas is $\boxed{51^\circ\text{C}}$.

(c)

Use the ideal gas equation to find the number of moles of the gas.

$$pV = nRT$$

Rewrite the equation to solve for n.

$$n = \frac{pV_i}{RT_i}$$

Substitute $3.0\times10^{-4}\ \text{m}^3$ for V_i, $973\ \text{K}$ for T_i, $3.039\times10^5\ \text{Pa}$ for p, and $8.314\ \text{J/mol}\cdot\text{K}$ for R.

$$\begin{aligned} n &= \frac{(3.039\times10^5\ \text{Pa})(3.0\times10^{-4}\ \text{m}^3)}{(8.314\ \text{J/mol}\cdot\text{K})(973\ \text{K})} \\ &= 0.011\ \text{mol} \end{aligned}$$

Thus, the number of moles of the gas is $\boxed{0.011\ \text{mol}}$.

Physics Example 8: Diagrammatic

Question:

A box is pulled by a rope with a force of 400 N along a horizontal surface. The angle the rope makes with the horizontal is 55°. Calculate the work done on the box and the power required to pull it a distance of 10.0 m in 20.0 s.

Solution:

The **work done** on an object is equal to the product of the force F applied on the object and the displacement d of the object. The expression for work done is as follows:

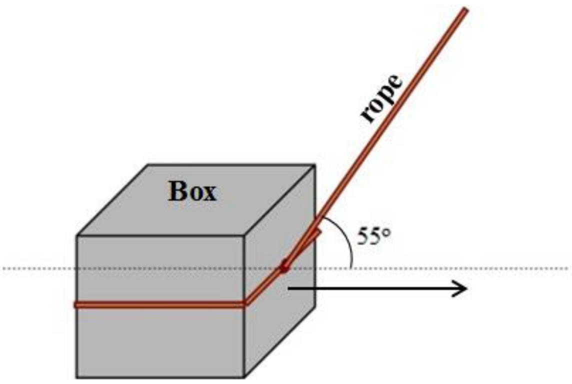
$$\begin{aligned} W &= F \cdot d \\ &= Fd\cos\theta \end{aligned}$$

Here, θ is the angle between the force vector and the displacement vector.

Power is defined as the ratio between the work done on an object W and the time interval t in which the work is done. The expression for power is as follows:

$$P = \frac{W}{t}$$

The following figure shows a box that is being pulled by a rope at an angle of 55°:



To determine the work done on the box, substitute 400 N for F, 10.0 m for d, and 55° for θ in the formula for work done.

$$\begin{aligned} W &= Fd\cos\theta \\ &= (400\text{ N})(10.0\text{ m})\cos 55^\circ \\ &= 2.3\times10^3\text{ J} \end{aligned}$$

Thus, the work done to pull the box is $\boxed{2.3\times10^3\text{ J}}$.

To calculate the power P required to pull the box, substitute $2.3\times10^3\ \text{J}$ for W and $20.0\ \text{s}$ for t in the formula for power.

$$
\begin{aligned}
P &= \frac{W}{t} \\
&= \frac{2.3\times10^3\ \text{J}}{20.0\ \text{s}} \\
&= 115\ \text{W}
\end{aligned}
$$

Thus, the power required to pull the box is $\boxed{115\ \text{W}}$.

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