# *Physics*

## *Unit 1: Introduction and Kinematics Review*

1. *Know about scientific method, units, fundamental units, unit prefixes, precision, accuracy, significant figures, vectors, scalars*
2. *Convert 120 Tm to m*
3. *In the process of delivering milk, a milkman, walks 100 m due east from his truck. He then turns around and walks 20 m due west. What is the milkman's displacement relative to his truck (magnitude and direction)? What distance did he travel?*
4. *A pigeon flew 10 km across town with an average speed of 5 m/s. How long, in hours, did it take the pigeon to make this journey?*
5. *A car, starting from rest, accelerates in a straight-line path at a constant rate of 2 $m/s^2$. How far will the car travel in 10 seconds?*
6. *The minimum takeoff speed for a certain airplane is 50 m/s. What minimum acceleration is required if the plane must leave a runway of length 2000 m? Assume the plane starts from rest at one end of the runway.*
7. *Water drips from rest from a leaf that is 2 m above the ground. Neglecting air resistance, what is the speed of each water drop when it hits the ground?*
8. *What maximum height will be reached by a stone thrown straight up with an initial speed of 5 m/s?*
9. *A cheetah is walking at a speed of 0.5 m/s when it observes a gazelle 15 m directly ahead. If the cheetah accelerates at 3 $m/s^2$, how long does it take the cheetah to reach the gazelle if the gazelle doesn't move?*
10. *Be able to read graphs and calculate speed, velocity, and acceleration from them.*
11. *A jumper in the long-jump goes into the jump with a speed of 5 m/s at an angle of 20° above the horizontal. What is the jumper's horizontal speed as they jump? What is their vertical speed?*
12. *A sailboat leaves a harbor and sails 21 km in the direction 15° north of east, where the captain stops for lunch. A short time later, the boat sails 2 km in the direction 75° south of east. What is the magnitude of the resultant displacement?*
13. *An eagle is flying due east at 5 m/s carrying a gopher in its talons. The gopher manages to break free at a height of 50 m. What is the magnitude of the gopher's velocity as it reaches the ground?*
14. *A ball is thrown horizontally from the top of a 100 m tall building with an initial speed of 5 m/s. How far from the base of the building did the ball land?*
15. *A swimmer swims with a velocity of 15 m/s south relative to the water. The current of the water is 2 m/s relative to the shore. If the current is moving west, what is the velocity of the swimmer relative to the shore?*

3. *Displacement:* $100\ m - 20\ m = \mathbf{80\ m}$;

*Distance:* $100\ m + 20\ m = \mathbf{120\ m}$

4. $\overline{v} = 5\frac{m}{s}, \Delta x = 10\ km$

*Convert:* $\frac{10\ km}{}\left(\frac{10^3\ m}{1\ km}\right) = 10000\ m$

$\overline{v} = \frac{\Delta x}{\Delta t}$

$5\frac{m}{s} = \frac{10000\ m}{t}$

$t = \frac{10000\ m}{5\frac{m}{s}} = \mathbf{2000\ s}$

*Convert:* $\frac{2000\ s}{}\left(\frac{1\ h}{3600\ s}\right) = 0.56\ h$

5. $a = 2\frac{m}{s^2}, t = 10\ s, v_0 = 0\frac{m}{s}, x = ?$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$x = 0\ m + \left(0\frac{m}{s}\right)(10\ s) + \frac{1}{2}\left(2\frac{m}{s^2}\right)(10\ s)^2$

$x = \mathbf{100\ m}$

6. $v = 50\frac{m}{s}, x = 2000\ m, v_0 = 0\frac{m}{s}, a = ?$

$v^2 = v_0^2 + 2a(x - x_0)$

$\left(50\frac{m}{s}\right)^2 = \left(0\frac{m}{s}\right)^2 + 2a(2000\ m - 0\ m)$

$2500\frac{m^2}{s^2} = (4000\ m)a$

$a = \mathbf{0.625\ m/s^2}$

7. $y_0 = 2\ m, v_0 = 0\frac{m}{s}, a = -9.8\frac{m}{s^2}, v = ?$

$v^2 = v_0^2 + 2a(y - y_0)$

$v^2 = \left(0\frac{m}{s}\right)^2 + 2\left(-9.8\frac{m}{s^2}\right)(0\ m - 2\ m)$

$v^2 = 39.2\frac{m^2}{s^2}$

$v = \mathbf{6.26\frac{m}{s}}$

8. $v_0 = 5\frac{m}{s}, v = 0\frac{m}{s}, a = -9.8\frac{m}{s^2}, y = ?$

$v^2 = v_0^2 + 2a(y - y_0)$

$\left(0\frac{m}{s}\right)^2 = \left(5\frac{m}{s}\right)^2 + 2\left(-9.8\frac{m}{s^2}\right)(y - 0\ m)$

$-25\frac{m^2}{s^2} = \left(-19.6\frac{m}{s^2}\right)y$

$y = \mathbf{1.28\ m}$

9. $v_0 = 0.5\frac{m}{s}, x = 15\ m, a = 3\frac{m}{s^2}, t = ?$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$15\ m = 0\ m + \left(0.5\frac{m}{s}\right)t + \frac{1}{2}\left(3\frac{m}{s^2}\right)t^2$

$0 = \left(\frac{3}{2}\frac{m}{s^2}\right)t^2 + \left(0.5\frac{m}{s}\right)t - 15\ m$

$t = \frac{-0.5 \pm \sqrt{(0.5)^2 - 4\left(\frac{3}{2}\right)(-15)}}{2\left(\frac{3}{2}\right)} = \mathbf{3\ s}, \cancel{-3.33\ s}$

11. *Horizontal:* $v_{0x} = 5\frac{m}{s}\cos 20° = \mathbf{4.70\frac{m}{s}}$

*Vertical:* $v_{0y} = 5\frac{m}{s}\sin 20° = \mathbf{1.71\frac{m}{s}}$

12.

| | x | y |
|---|---|---|
| 21 km @ 15° N of E | 20.28 | 5.44 |
| 2 km @ 75° S of E | 0.52 | -1.93 |
| | 20.80 | 3.51 |

$r = \sqrt{20.80^2 + 3.51^2} = 21.1\ km$

$\theta = tan^{-1}\frac{3.51}{20.80} = 9.67°\ N\ of\ E$

13. $x: v_{0x} = 5\frac{m}{s}, y: v_{0y} = 0\frac{m}{s}, y_0 = 50\ m, a_y = -9.8\frac{m}{s^2}, y = 0\ m, v_y = ?$

$v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$

$v_y^2 = \left(0\frac{m}{s}\right)^2 + 2\left(-9.8\frac{m}{s^2}\right)(0\ m - 50\ m)$

$v_y^2 = 980\frac{m}{s}$

$v_y = 31.30\frac{m}{s}$

*combine:* $v = \sqrt{v_x^2 + v_y^2}$

$v = \sqrt{\left(5\frac{m}{s}\right)^2 + \left(31.30\frac{m}{s}\right)^2} = \mathbf{31.7\ m/s}$

14. $x: v_{0x} = 5\frac{m}{s}, x = ?;\ y: y_0 = 100\ m, y = 0\ m, a = -9.8\frac{m}{s^2}, v_{0y} = 0\frac{m}{s}$

*find t:* $y = y_0 + v_{0y}t + \frac{1}{2}at^2$

$0\ m = 100\ m + \left(0\frac{m}{s}\right)t + \frac{1}{2}\left(-9.8\frac{m}{s^2}\right)t^2$

$-100\ m = \left(-4.9\frac{m}{s^2}\right)t^2$

$20.41\frac{m^2}{s^2} = t^2$

$t = \mathbf{4.52\ s}$

*find x:* $x = x_0 + v_{0x}t$

$x = 0 + \left(5\frac{m}{s}\right)(4.52\ s) = \mathbf{22.6\ m}$

15. $v_{SW} = 15\frac{m}{s}\ South, v_{WG} = 2\frac{m}{s}\ West$

$v_{SG} = v_{SW} + v_{WG}$

| | x | y |
|---|---|---|
| 15 m/s S | 0 | -15 |
| 2 m/s W | -2 | 0 |
| | -2 | -15 |

$v_{SG} = \sqrt{(-2)^2 + (-15)^2} = 15.1\ m/s$

$\theta = tan^{-1} - \frac{15}{-2} = 82.4°$

$v_{SG} = \mathbf{15.1\frac{m}{s}\ at\ 82.4°\ S\ of\ W}$

# *Physics*

*Unit 2: Forces and Uniform Circular Motion*

1. *Terms like Velocity, Force, Acceleration, Equilibrium, Inertia, apparent weight, Normal force, True Weight, Gravitational Force, Applied force, Tension, Uniform Circular Motion, Period, Revolution, radius, centripetal acceleration, centripetal force, banked and unbanked curves, satellites, orbit, weightlessness, artificial gravity, Kepler's Laws of Planetary Motion*
2. *Fundamental forces*
3. *Difference between g and G*
4. *static and kinetic frictional forces*
5. *List Newton's Three Laws of Motion.*
6. *difference between mass and weight*
7. *What forces do you draw on a freebody diagram?*
8. *How is centripetal force different from all the other forces we have studied?*
9. *A 100-N force acts on a 75-kg person. What is the acceleration of the person?*
10. *A 70-kg ice skater pushes on a box on smooth ice (no friction). He applies 200 N horizontally against the 50-kg box. What are the accelerations of the ice skater and the box?*
11. *A 10-kg block rests on a frictionless plane inclined at 60°. What is the acceleration of the block as it slides down the incline?*
12. *A stoplight is suspended by two cables over a street. Weight of the light is 110 N and the cables make a 116° angle with each other. Find the tension in each cable.*
13. *A 100-kg man is standing on a bathroom scale while riding an elevator. What does the scale read when the elevator is accelerating upward at 5 m/s$^2$?*
14. *A 5000-kg car skids to a stop. $\mu_k$ = .5. What is the magnitude of the friction force?*
15. *Find the terminal velocity of a falling mouse in air ($A = 0.004\ m^2$, $m = 0.02\ kg$, $C = 0.5$).*
16. *Convert the angular measure of 40 degrees to radians.*
17. *A stone is in a sling and a boy whirls it around in a circle. If the centripetal acceleration is 50 m/s$^2$ and the radius of the circle is 10 cm, what is the speed of the stone?*
18. *Find the gravitational force of attraction between a 100-kg girl and a 200-kg boy sitting 0.5 meters apart.*
19. *What is the acceleration due to gravity at an altitude of $1 \times 10^6\ m$ above the earth's surface? **Note:** the radius of the earth is $6.36 \times 10^6\ m$.*
20. *Four people are having a tug-o-war game. Ashley pulls left with 20 N, Bert pulls left with 10 N, Charlie pulls right with 30 N, and Dannie pulls right with 5 N. What is the magnitude of the acceleration of the 5 kg rope and who wins the game?*
21. *A 10-g nut is hanging from a spring that has stretched 30 cm because a squirrel is pulling it down. If the squirrel is pulling with 300 N, what is the spring constant?*

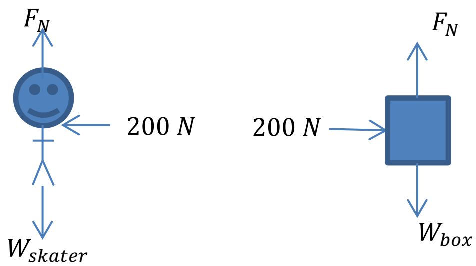
7. *Only forces acting on the object*

9. $F = ma$

$100\ N = 75\ kg\ (a)$

$a = \mathbf{1.33\frac{m}{s^2}}$

10.




14. $F_y: F_N - W = 0 \rightarrow F_N = W \rightarrow F_N =$

$(5000\ kg)\left(9.8\frac{m}{s^2}\right) = 49000\ N$

$F_x: f_k = \mu_k F_N = 0.5(49000\ N) = \mathbf{24500\ N}$

15. *Mouse:* $v = \sqrt{\frac{2mg}{\rho CA}}$

$v = \sqrt{\frac{2(0.02\ kg)\left(9.8\frac{m}{s^2}\right)}{\left(1.21\frac{kg}{m^3}\right)(0.5)(0.004\ m^2)}} = \mathbf{12.7\frac{m}{s}}$

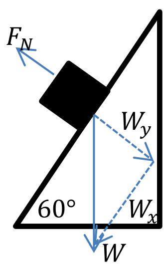
16. $40°\left(\frac{\pi}{180°}\right) = \mathbf{\frac{2\pi}{9}}$

$W_{skater} = 70\ kg\ \left(9.8\frac{m}{s^2}\right)$
$= 686\ N$

$W_{box} = 50\ kg\ \left(9.8\frac{m}{s^2}\right)$
$= 490\ N$

| $x$ | $y$ | $x$ | $y$ |
|---|---|---|---|
| $-200\ N$ | $F_N$<br>$W = -686\ N$ | $200\ N$ | $F_N$<br>$W = -490\ N$ |
| $F = ma$<br>$-200\ N = 70\ kg\ (a)$<br>$a_{skater} = \mathbf{-2.86\ m/s^2}$ | | $F = ma$<br>$200\ N = 50\ kg\ (a)$<br>$\mathbf{a_{box} = 4.0\ m/s^2}$ | |

11. $W = 10\ kg\ \left(9.8\frac{m}{s^2}\right) = 98\ N$




| $x$ | $y$ |
|---|---|
| $W_x = -W\sin 60°$ | $F_N$<br>$W_y = -W\cos 60°$ |

*Forces in x:* $F = ma$

$-W\sin 60° = ma$

$-98\ N\sin 60° = 10\ kg\ (a)$

$a = \mathbf{-8.49\frac{m}{s^2}}$

12. $F_x: T_2\cos 32° - T_1\cos 32° = 0$

$T_2(.8480) - T_1(.8480) = 0$

$T_1 = T_2$

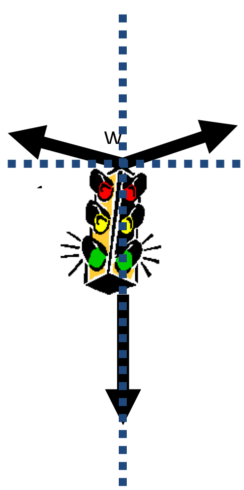
$F_y: -W + T_1\sin 32° + T_2\sin 32° = 0$

$-110\ N + T_1(.5299) + T_1(.5299) = 0$

$-110\ N + 1.0598\ T_1 = 0$

$1.0598\ T_1 = 110\ N$

$T_1 = T_2 = \mathbf{103.8\ N}$




13. $F_N - W = ma$

$F_N - (100\ kg)\left(9.8\frac{m}{s^2}\right) = (100\ kg)\left(5\frac{m}{s^2}\right)$

$F_N = \mathbf{1480\ N}$

17. $a_c = \frac{v^2}{r}$

$50\frac{m}{s^2} = \frac{v^2}{0.10\ m}$

$v^2 = 5m^2/s^2$

$v = \mathbf{2.24\ m/s}$

18. $F_g = G\frac{mM}{r^2}$

$F_g = 6.67\times10^{-11}\frac{Nm^2}{kg^2}\frac{(100\ kg)(200\ kg)}{(0.5\ m)^2} = \mathbf{5.34\times 10^{-6}\ N}$

19. $g = G\frac{M}{r^2}$

$g = \frac{\left(6.67\times10^{-11}\frac{Nm^2}{kg^2}\right)(5.98\times10^{24}\ kg)}{(1\times10^6\ m+6.36\times10^6\ m)^2} = \mathbf{7.36\ m/s^2}$

20. $F_{net} = ma$

$-20\ N - 10\ N + 30\ N + 5\ N = (5\ kg)a$

$a = 1\ m/s^2$

*since this is to the right Charlie and Dannie win*

21. $kx - mg - F_{sq} = ma = 0$

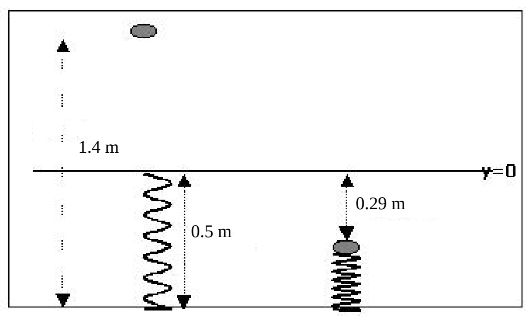
$k(0.3\ m) - (0.01\ kg)\left(9.8\frac{m}{s^2}\right) - 300\ N = 0$

$k = 1000$

# Physics

## Unit 3: Work, Energy, and Momentum

1. *Meanings and concepts of terms like work, kinetic energy, gravitational potential energy, Conservation of mechanical energy, work-energy theorem, conservative force, nonconservative, elastic and inelastic collisions, impulse, momentum, isolated system, conserved*
2. *Know how force and time are related to collisions and impulse.*
3. *When is linear momentum and kinetic energy is conserved.*
4. *Mike is cutting the grass using a human-powered lawn mower. He pushes the mower with a force of 100 N directed at an angle of 20° below the horizontal direction. Calculate the work that Mike does on the mower in pushing it 5 m across the yard.*
5. *The kinetic energy of a car is 7000 J as it travels along a horizontal road. How much work is required to stop the car in 20 s?*
6. *A 15-kg block is lifted vertically 10 meters from the surface of the earth. To one significant figure, what is the change in the gravitational potential energy of the block?*
7. *An engineer is asked to design a playground slide such that the speed a child reaches at the bottom does not exceed 4.0 m/s. Determine the maximum height that the slide can be.*
8. *A ball of mass 5-kg is dropped from a height of 1.4 m (from the ground) onto a massless spring (the spring has an equilibrium length of 0.5 m). The ball compresses the spring by an amount of 0.29 m by the time it comes to a stop. Calculate the spring constant of the spring.*




9. *A warehouse worker uses a forklift to lift a crate of pickles on a platform to a height 5 m above the floor. The combined mass of the platform and the crate is 100 kg. If the power expended by the forklift is 2000 W, how long does it take to lift the crate?*
10. *Jennifer is walking at 0.5 m/s. If Jennifer weighs 980 N, what is the magnitude of her momentum?*
11. *A 10.0-kg steel ball is dropped straight down onto a hard horizontal floor and bounces straight up. Its speed just before and just after impact with the floor is 100 m/s. Determine the magnitude of the impulse delivered to the floor by the steel ball.*
12. *A 5000-kg cannon at rest contains a 100-kg cannon ball. When fired, the cannon ball leaves the cannon with a speed of 20 m/s. What is the recoil speed of the cannon?*
13. *A 2000-kg car traveling east at 50 m/s collides with a 500-kg car traveling west at 30 m/s. The cars stick together after the collision. What is their common velocity after the collision?*
14. *A driver slams on the brakes of a 900-kg car going at 40 m/s so that the wheels lock. The road is sloping upwards. If the car stops 20 m higher than it started, what is the work that friction did to stop the car?*

4. $F = 100\ N\ @20°, s = 5\ m$
$W = Fs\cos\theta = (100\ N)(5\ m)\cos 20° =$
$\mathbf{470\ J}$

5. $KE_0 = 7000\ J, t = 20\ s$
$W = KE_f - KE_0 = 0 - 7000\ J =$
$\mathbf{-7000\ J}$

6. $m = 15\ kg, h = 10\ m$
$PE = mgh = (15\ kg)\left(9.8\frac{m}{s^2}\right)(10\ m) =$
$\mathbf{1470\ J}$

7. $v_f = 4\frac{m}{s}$
$PE_f + KE_f = PE_0 + KE_0$
$\cancel{m}gh_f + \frac{1}{2}\cancel{m}v_f^2 = \cancel{m}gh_0 + \frac{1}{2}\cancel{m}v_0^2$
$\left(9.8\frac{m}{s^2}\right)(0\ m) + \frac{1}{2}\left(4\frac{m}{s}\right)^2 = \left(9.8\frac{m}{s^2}\right)h_0 +$
$\frac{1}{2}\left(0\frac{m}{s}\right)^2$
$8\frac{m^2}{s^2} = 9.8\frac{m}{s^2}\ h_0$
$h_0 = \mathbf{0.816\ m}$

8. $m = 5\ kg, h_0 = 1.4\ m, h_f = 0.5\ m -$
$0.29\ m = 0.21\ m, x = 0.29\ m$
$KE_0 + PE_0 = KE_f + PE_f$
$0 + mgh_0 = 0 + mgh_f + \frac{1}{2}kx^2$
$(5\ kg)\left(9.8\frac{m}{s^2}\right)(1.4\ m) =$
$(5\ kg)\left(9.8\frac{m}{s^2}\right)(0.21\ m) + \frac{1}{2}k(0.29\ m)^2$
$68.6\ J = 10.29\ J + (0.04205\ m^2)k$
$58.31\ J = (0.04205\ m^2)k$
$k = \mathbf{1387\ \frac{N}{m}}$

9. $h = 5\ m, m = 100\ kg, P = 2000\ W$
$P = \frac{W}{t} = \frac{Fs}{t} = \frac{mas}{t}$
$2000\ W = \frac{(100\ kg)\left(9.8\frac{m}{s^2}\right)(5\ m)}{t}$
$t = \mathbf{2.45\ s}$

**10.** $W = mg \rightarrow 980\ N = m\left(9.8\frac{m}{s^2}\right) \rightarrow m =$
$100\ kg$
$p = mv$
$p = (100\ kg)\left(0.5\frac{m}{s}\right) = \mathbf{50\ kg\frac{m}{s}}$

11. $m = 10\ kg, v_0 = -100\frac{m}{s}, v_f = 100\frac{m}{s}$
$J = F \cdot t = mv_f - mv_0$
$J =$
$(10\ kg)\left(100\frac{m}{s}\right) - (10\ kg)\left(-100\frac{m}{s}\right) =$
$\mathbf{2000\ Ns}$

12. $m_c = 5000\ kg, v_{0c} = 0, v_{fc} = ?$
$m_b = 100\ kg, v_{0b} = 0, v_{fb} = 20\frac{m}{s}$
$m_c v_{0c} + m_b v_{0b} = m_c v_{fc} + m_b v_{fb}$
$(5000\ kg)(0) + (100\ kg)(0) =$
$(5000\ kg)v_{fc} + (100\ kg)\left(20\frac{m}{s}\right)$
$0 = (5000\ kg)v_{fc} + 2000\ kg\frac{m}{s}$
$-2000\ kg\frac{m}{s} = (5000\ kg)v_{fc}$
$v_{fc} = \mathbf{-0.40\frac{m}{s}}$

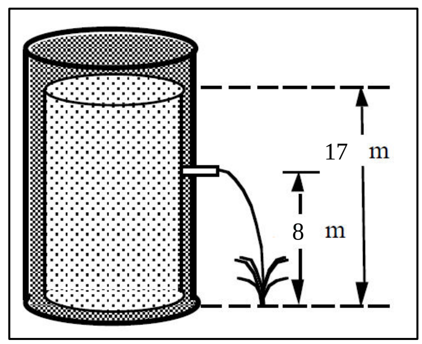
13. $m_1 = 2000\ kg, v_{01} = 50\frac{m}{s}, v_{f1} = ?$
$m_2 = 500\ kg, v_{02} = -30\frac{m}{s}, v_{f2} = ?$
$m_1 v_{01} + m_2 v_{02} = m_1 v_{f1} + m_2 v_{f2}$
$(2000\ kg)\left(50\frac{m}{s}\right) + (500\ kg)\left(-30\frac{m}{s}\right) =$
$(2000\ kg)v_f + (500\ kg)v_f$
$85000\ kg\frac{m}{s} = 2500\ kg\ v_f$
$v_f = \mathbf{34\ m/s}$

14. $E_0 + W_{nc} = E_f$
$$\frac{1}{2}mv_0^2 + W_{nc} = mgh_f$$
$$\frac{1}{2}(900\ kg)\left(40\frac{m}{s}\right)^2 + W_{nc}$$
$$= (900\ kg)\left(9.8\frac{m}{s^2}\right)(20\ m)$$
$$720000\ J + W_{nc} = 176400\ J$$
$$W_{nc} = -5.44 \times 10^5\ J$$

# *Physics*

*Unit 5: Fluids*

1. *Meanings and concepts of terms like fluid, density, barometer, Pascal's principle, Bernoulli's principle, Archimedes' principle, continuity equation, pressure, buoyant force, gauge pressure, absolute pressure, Poiseuille's Law, laminar flow, turbulent flow, osmosis, dialysis, diffusion*
2. *The density of mercury is* $1.36 \times 10^4$ *kg/m³. What is the mass of a 10-m³ sample of mercury?*
3. *The average density of the material in intergalactic space is approximately* $2.5 \times 10^{-27}$ *kg/m³. What is the volume of a gold sample, ρ = 19300 kg/m³, that has the same mass as* $5 \times 10^{24}$ *m³ of intergalactic space?*
4. *A barometer is taken from the base to the top of a 10-m tower. Assuming the density of air is 1.29 kg/m³, what is the measured change in pressure?*
5. *How much force does the atmosphere exert on one side of a vertical wall 10-m high and 20-m long?*
6. *A force of 500 N is applied to a hydraulic jack piston that is 0.01 m in diameter. If the piston which supports the load has a diameter of 2 m, approximately how much mass can be lifted by the jack? Ignore any difference in height between the pistons.*
7. *A balloon inflated with helium gas (density = 0.2 kg/m³) has a volume of 5 m³. If the density of air is 1.3 kg/m³, what is the buoyant force exerted on the balloon?*
8. *Water enters a pipe of diameter 10 cm with a velocity of 5 m/s. The water encounters a constriction where its velocity is 20 m/s. What is the diameter of the constricted portion of the pipe?*
9. *A large tank is filled with water to a depth of 17 m. A spout located 8 m above the bottom of the tank is then opened as shown in the drawing. With what speed will water emerge from the spout?*




10. *A small crack occurs at the base of a 10 .0-m-high dam. The effective crack area through which water leaves is* $1.30 \times 10^{-3}$ *m². Ignoring viscous losses, what is the speed of the water flowing through the crack?*
11. *Water flows through a pipe with radius 2 m and speed of 10 m/s. The density of water is 1000 kg/m³ and its viscosity is* $1.002 \times 10^{-3}$ *Pa•s. Calculate the Reynold's number for this situation.*
12. *About how long will it take a perfume molecule to diffuse a distance of 2 m in one direction in a room if the diffusion constant is* $5 \times 10^{-3}$ *m²/s? Assume that the air is perfectly still.*
13. *The density of ice is 800 kg/m³; and the density of seawater is 900 kg/m³. A large iceberg floats in Arctic waters. What fraction of the volume of the iceberg is exposed?*

2. $\rho = 1.36 \times 10^4 \frac{kg}{m^3}, V = 10\ m^3$

$\rho = \frac{m}{V}$

$1.36 \times 10^4 \frac{kg}{m^3} = \frac{m}{10\ m^3}$

$m = \mathbf{1.36 \times 10^5\ kg}$

3. $\rho_{space} = 2.5 \times 10^{-27} \frac{kg}{m^3}, \rho_{gold} = 19300 \frac{kg}{m^3}, V_{space} = 5 \times 10^{24}\ m^3$

$\rho = \frac{m}{V}$

$2.5 \times 10^{-27} \frac{kg}{m^3} = \frac{m}{5 \times 10^{24}\ m^3}$

$m = 0.0125\ kg$

$19300 \frac{kg}{m^3} = \frac{0.0125\ kg}{V}$

$V = \mathbf{6.48 \times 10^{-7}\ m^3}$

4. $h = 10\ m, \rho_{air} = 1.29 \frac{kg}{m^3}$

$P = h\rho g$

$P = (10\ m)\left(1.29 \frac{kg}{m^3}\right)\left(9.8 \frac{m}{s^2}\right) = \mathbf{126\ Pa}$

**5.** $h = 10\ m, \ell = 20\ m$

$P = \frac{F}{A}$

$1.01 \times 10^5\ Pa = \frac{F}{(10\ m)(20\ m)}$

$F = \mathbf{2.02 \times 10^7\ N}$

6. $F_1 = 500\ N, d_1 = 0.01\ m, d_2 = 2\ m$

$\frac{F_1}{A_1} = \frac{F_2}{A_2}$

$\frac{500\ N}{\pi(0.005\ m)^2} = \frac{F_2}{\pi(1\ m)^2}$

$F_2 = 2.0 \times 10^7\ N$

$W = mg$

$m = \frac{W}{g} = \frac{2.0 \times 10^7\ N}{9.8\ m/s^2} = \mathbf{2.04 \times 10^6\ kg}$

7. $\rho_{He} = 0.2 \frac{kg}{m^3}, V = 5\ m^3, \rho_{air} = 1.3 \frac{kg}{m^3}$

$F_B = w_{fl}$

$F_B = m_{air} g$

$\rho = \frac{m}{V}$

$1.3 \frac{kg}{m^3} = \frac{m_{air}}{5\ m^3}$

$m_{air} = 6.5\ kg$

$F_B = (6.5\ kg)\left(9.8 \frac{m}{s^2}\right) = \mathbf{63.7\ N}$

8. $d_1 = 10\ cm, v_1 = 5 \frac{m}{s}, v_2 = 20 \frac{m}{s}$

$A_1 \overline{v}_1 = A_2 \overline{v}_2$

$(\pi(0.05\ m)^2)\left(5 \frac{m}{s}\right) = (\pi r_2^2)\left(20 \frac{m}{s}\right)$

$r_2 = 0.025\ m$

$d_2 = \mathbf{0.05\ m}$

9. $h_1 = 17\ m, h_2 = 8\ m, \rho = 1000 \frac{kg}{m^3}$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

$1\ atm + 0 + \left(1000 \frac{kg}{m^3}\right)\left(9.8 \frac{m}{s^2}\right)(17\ m)$

$= 1\ atm + \frac{1}{2}\left(1000 \frac{kg}{m^3}\right) v_2^2$

$+ \left(1000 \frac{kg}{m^3}\right)\left(9.8 \frac{m}{s^2}\right)(8\ m)$

$166600 \frac{N}{m^2} = \left(500 \frac{kg}{m^3}\right) v_2^2 + 78400 \frac{N}{m^2}$

$88200 \frac{N}{m^2} = \left(500 \frac{kg}{m^2}\right) v_2^2$

$v_2 = \mathbf{13.3 \frac{m}{s}}$

10. $P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

$1\ atm + 0 + \left(1000 \frac{kg}{m^3}\right)\left(9.8 \frac{m}{s^2}\right)(10\ m)$

$= 1 atm + \frac{1}{2}\left(1000 \frac{kg}{m^3}\right) v_2^2 + 0$

$98000 \frac{J}{m^2} = 500 \frac{kg}{m^3}\ v_2^2$

$v_2 = 14 \frac{m}{s}$

11. $r = 2\ m, v = 10 \frac{m}{s}, \rho = 1000 \frac{kg}{m^3}, \eta = 1.002 \times 10^{-3} Pa \cdot s$

$N_R = \frac{2\rho v\ r}{\eta}$

$N_R = \frac{2\left(1000 \frac{kg}{m^3}\right)\left(10 \frac{m}{s}\right)(2\ m)}{1.002 \times 10^{-3} Pa \cdot s}$

$N_R = \mathbf{3.99 \times 10^7}$

**12.** $x = 2\ m, D = 5 \times 10^{-3} \frac{m^2}{s}$

$x_{rms} = \sqrt{2Dt}$

$2\ m = \sqrt{2\left(5 \times 10^{-3} \frac{m^2}{s}\right) t}$

$4\ m^2 = 10 \times 10^{-3} \frac{m^2}{s} \cdot t$

$t = \mathbf{400\ s}$

13. $\rho_{ice} = 800 \frac{kg}{m^3}, \rho = 900 \frac{kg}{m^3}$

$Fraction\ submerged = \frac{\rho_{obj}}{\rho_{fl}}$

$Fraction\ submerged = \frac{800 \frac{kg}{m^3}}{900 \frac{kg}{m^3}}$

$Fraction\ submerged = \frac{8}{9} = 88.9\ \%$

$Fraction\ exposed = 1 - Fraction\ submerged$

$Fraction\ exposed = 1 - \frac{8}{9}$

$Fraction\ exposed = \mathbf{\frac{1}{9}} = \mathbf{11.1}\ \%$

# *Physics*

*Unit 6: Temperature, Heat, and Thermodynamics*

1. *Meanings and concepts of terms like thermal expansion, equilibrium, condensation, evaporation, sublimation, freezing, melting, humidity, heat, calorimeter, convection, conduction, radiation, blackbody radiator, thermodynamics, heat engine, heat pump, Carnot engine, entropy*
2. *The coefficient of linear expansion of aluminum is* $2.3 \times 10^{-6}$ */C°. A circular hole in an aluminum plate is 10 cm in diameter at 10 °C. What is the diameter of the hole if the temperature of the plate is raised to 100 °C?*
3. *A sample of a monatomic ideal gas is originally at 20 °C. What is the final temperature of the gas if both the pressure and volume are quadrupled?*
4. *Late on an autumn day, the relative humidity is 60% and the temperature in 30 °C. What will the relative humidity be that evening when the temperature has dropped to 10 °C, assuming constant water vapor density?*
5. *A 5-kg lead shot is heated to 200 °C and dropped into an ideal calorimeter containing 10 kg of water initially at 20.0 °C. What is the final equilibrium temperature of the lead shot? The specific heat capacity of lead is 128 J/(kg·C°); and the specific heat of water is 4186 J/(kg·C°).*
6. *What is the minimum amount of energy required to completely melt a 5-kg lead brick which has a starting temperature of 20 °C? The melting point of lead is 328 °C. The specific heat capacity of lead is 128 J/(kg·C°); and its latent heat of fusion is 23200 J/kg.*
7. *A blue supergiant star has a radius of* $5\times10^{10}$ *m. The spherical surface behaves as a blackbody radiator. If the surface temperature is* $5\times10^{4}$ *K, what is the rate at which energy is radiated from the star?*
8. *At what rate is heat lost through a 5 m × 10 m rectangular glass windowpane that is 0.5 cm thick when the inside temperature is 20 °C and the outside temperature -5 °C? The thermal conductivity for glass is 0.80 W/(m·C°).*
9. *A system containing an ideal gas at a constant pressure of* $5\times10^{5}$ *Pa gains 100 J of heat. During the process, the internal energy of the system increases by 500 J. What is the change in volume of the gas?*
10. *An engine is used to lift a 5000 kg truck to a height of 2 m at constant speed. In the lifting process, the engine received* $5\times10^{5}$ *J of heat from the fuel burned in its interior. What is the efficiency of the engine?*
11. *A Carnot heat engine is to be designed with an efficiency of 60%. If the low temperature reservoir is 20 °C, what is the temperature of the "hot" reservoir?*
12. *If the coefficient of performance for a refrigerator is 6 and 1000 J of work are done on the system, how much heat is rejected to the room?*
13. *A 20-kg sample of steam at 100.0 °C condenses to water at 100.0 °C. What is the entropy change of the sample if the heat of vaporization of water is* $2.26\times10^{6}$ *J/kg?*

2. $\alpha = 2.3 \times 10^{-6}/C°, d_1 = 0.05\ m, T_1 = 10\ °C, T_2 = 100\ °C$
$\Delta L = \alpha L \Delta T$
$\Delta L = (2.3 \times 10^{-6}\ /C°)(0.05\ m)(100\ °C - 10\ °C)$
$\Delta L = 1.04 \times 10^{-5}\ m$
$d_2 = 0.05\ m + 1.04 \times 10^{-5}\ m = \mathbf{5.001 \times 10^{-2}\ m}$

3. $T_1 = 20\ °C, P_2 = 4P_1, V_2 = 4V_1$
$PV = nRT$
$\frac{PV}{T} = nR$
*since nR is constant*
$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
$\frac{P_1V_1}{20\ °C} = \frac{(4P_1)(4V_1)}{T_2}$
$\frac{1}{20\ °C} = \frac{16}{T_2}$
$T_2 = \mathbf{320\ °C}$

4. $\%\ hum_1 = 60\ \%, T_1 = 30\ °C, T_2 = 10\ °C$
*% relative humidity*
$$= \frac{vapor\ density}{saturation\ vapor\ density} \times 100\%$$
$60\ \% = \frac{vapor\ density}{30.4 \frac{g}{m^3}} \times 100\%$
$vapor\ denstiy = 18.24 \frac{g}{m^3}$
$\%\ humid = \frac{18.24 \frac{g}{m^3}}{9.4 \frac{g}{m^3}} \times 100\%$
$\%\ humidity = \mathbf{194}\ \%$
This can't really happen. It started raining and the humidity stayed at 100%.

5. $m_l = 5\ kg, T_l = 200\ °C, m_w = 10\ kg, T_w = 20°C, c_l = 128 \frac{J}{kg \cdot C°}, c_w = 4186 \frac{J}{kg \cdot C°}$
$Q = mc\Delta T$
$Q_l = -Q_w$
$(5\ kg)\left(128 \frac{J}{kg \cdot C°}\right)(T_f - 200°C)$
$$= -(10\ kg)\left(4186 \frac{J}{kg \cdot C°}\right)(T_f - 20\ °C)$$
$640 \frac{J}{C°} T_f - 128000\ J = -41860 \frac{J}{C°} T_f + 837200\ J$
$42500 \frac{J}{C°} T_f = 965200\ J$
$T_f = \mathbf{22.7\ °C}$

6. $m = 5\ kg, T_0 = 20\ °C, T_{melt} = 328\ °C, c = 128 \frac{J}{kg \cdot C°}, L_f = 23200 \frac{J}{kg}$
$Q = mc\Delta T$
$Q = (5\ kg)\left(128 \frac{J}{kg \cdot C°}\right)(328\ °C - 20\ °C)$
$Q = 197120\ J$
$Q_{melt} = mL_f$
$Q_{melt} = (5\ kg)\left(23200 \frac{J}{kg}\right) = 116000\ J$
$Q_{tot} = 197120\ J + 116000\ J = \mathbf{313120\ J}$

7. $r = 5 \times 10^{10} m, T = 5 \times 10^4 K, e = 1$
$\frac{Q}{t} = \sigma e A T^4$
$\frac{Q}{t} = \left(5.67 \times 10^{-8} \frac{J}{s \cdot m^2 \cdot K^4}\right)(1)(4\pi(5 \times 10^{10}\ m)^2)(5 \times 10^4\ K)^4$
$\frac{Q}{t} = \mathbf{1.11 \times 10^{34} \frac{J}{s}}$

8. $A = (5\ m)(10\ m) = 50\ m^2, d = 0.005\ m, T_2 = -5\ °C, T_1 = 20\ °C, k = 0.80 \frac{W}{m \cdot C°}$
$\frac{Q}{t} = \frac{kA(T_2 - T_1)}{d}$
$\frac{Q}{t} = \frac{\left(0.80 \frac{W}{m \cdot C°}\right)(50\ m^2)(-5\ °C - 20\ °C)}{0.005\ m}$
$\frac{Q}{t} = \mathbf{-200000 \frac{J}{s}}$

**9.** $P = 5 \times 10^5\ Pa, Q = 100\ J, \Delta U = 500\ J$
$\Delta U = Q - W$
$500\ J = 100\ J - W$
$W = -600\ J$
$W = P\Delta V$ *(isobaric process)*
$-600\ J = (5 \times 10^5\ Pa)\Delta V$
$\Delta V = \mathbf{-0.0012\ m^3}$

10. $m = 5000\ kg, h = 2\ m, Q = 5 \times 10^5\ J$
$Eff = \frac{W}{Q_h}$
$Eff = \frac{(5000\ kg)\left(9.8 \frac{m}{s^2}\right)(2\ m)}{5 \times 10^5\ J} = \mathbf{0.196}$

11. $Eff_C = 0.60, T_c = 20\ °C$
$Eff_C = 1 - \frac{T_c}{T_h}$
$0.60 = 1 - \frac{20\ °C}{T_h}$
$-0.40 = -\frac{20°C}{T_h}$
$T_h = \frac{20\ °C}{-0.40} = \mathbf{-50\ °C}$

12. $COP_{ref} = 6, W = 1000\ J$
$COP_{ref} = \frac{Q_c}{W}$
$6 = \frac{Q_c}{1000\ J}$
$Q_c = \mathbf{6000\ J}$

13. $m = 20\ kg, T = 100\ °C, L_v = 2.26 \times 10^6 \frac{J}{kg}$
$\Delta S = \frac{Q}{T}$
$\Delta S = \frac{(20\ kg)\left(2.26 \times 10^6 \frac{J}{kg}\right)}{100\ °C} = \mathbf{452000 \frac{J}{K}}$