Solutions

The area of a circle is given by: [A = \pi r^2] where (r) is the radius of the circle.

```
import math
radius = 5  # units
area = math.pi * (radius ** 2)
```

1. To calculate the average velocity, use the formula: $\text{average velocity} = \frac{\text{initial velocity} + \text{final velocity}}{2}$

   ```
   initial_velocity = 10  # m/s
   final_velocity = 20  # m/s
   average_velocity = (initial_velocity + final_velocity) / 2
   ```

2. The gravitational force between two masses is given by Newton's law of gravitation: $$ F = G \frac{m_1 m_2}{r^2} $$ where (G) is the gravitational constant.

   ```
   G = 6.67430e-11  # gravitational constant
   mass1 = 5.0  # kg
   mass2 = 10.0  # kg
   distance = 2.0  # m
   gravitational_force = G * (mass1 * mass2) / (distance ** 2)
   ```

3. The kinetic energy of an object is given by: $$ KE = \frac{1}{2} m v^2 $$

   ```
   mass = 2.0  # kg
   velocity = 3.0  # m/s
   kinetic_energy = 0.5 * mass * (velocity ** 2)
   ```

4. The potential energy of an object at a height is given by: $$ PE = mgh $$ where (g) is the acceleration due to gravity.

   ```
   mass = 2.0  # kg
   height = 5.0  # m
   g = 9.8  # m/s^2
   potential_energy = mass * g * height
   ```

5. The work done by a force over a distance is given by: $$ W = Fd $$

   ```
   ```

```
force = 10.0  # N
distance = 5.0  # m
work_done = force * distance
```

6. The power output of a machine is given by: $$ P = \frac{W}{t} $$

```
work_done = 100.0  # J
time_taken = 5.0  # s
power_output = work_done / time_taken
```

7. The acceleration of an object is given by: $$ a = \frac{v_f - v_i}{t} $$

```
initial_velocity = 0  # m/s
final_velocity = 20  # m/s
time_taken = 4  # s
acceleration = (final_velocity - initial_velocity) / time_taken
```

8. The momentum of an object is given by: $$ p = mv $$

```
mass = 2.0  # kg
velocity = 3.0  # m/s
momentum = mass * velocity
```

9. The impulse experienced by an object is given by: $$ J = Ft $$

```
force = 10.0  # N
time_duration = 2.0  # s
impulse = force * time_duration
```

10. The frequency of a wave is given by: $$ f = \frac{v}{\lambda} $$

```
wavelength = 2.0  # m
speed = 340.0  # m/s
frequency = speed / wavelength
```

11. The period of a pendulum is given by: $$ T = 2\pi \sqrt{\frac{L}{g}} $$

```
length = 2.0  # m
g = 9.8  # m/s^2
period = 2 * 3.14159 * (length / g) ** 0.5
```

12. The electric force between two charges is given by Coulomb's law: $$ F = k \frac{q_1 q_2}{r^2} $$ where (k) is Coulomb's constant.

```
k = 8.99e9  # N m^2/C^2
charge1 = 1e-6  # C
charge2 = 2e-6  # C
distance = 0.5  # m
electric_force = k * (charge1 * charge2) / (distance ** 2)
```

13. The electric field at a point due to a point charge is given by: $$ E = k \frac{q}{r^2} $$

```
k = 8.99e9  # N m^2/C^2
charge = 1e-6  # C
distance = 0.5  # m
electric_field = k * charge / (distance ** 2)
```

14. The potential difference between two points in an electric field is given by: $$ V = Ed $$

```
electric_field = 1000  # N/C
distance = 0.1  # m
potential_difference = electric_field * distance
```

15. The capacitance of a parallel plate capacitor is given by: $$ C = \frac{\epsilon_0 A}{d} $$ where (\epsilon_0) is the permittivity of free space.

```
epsilon_0 = 8.85e-12  # F/m
area = 1.0  # m^2
distance = 0.01  # m
capacitance = epsilon_0 * area / distance
```

16. The magnetic force on a moving charge in a magnetic field is given by: $$ F = qvB $$

```
charge = 1e-6  # C
velocity = 10.0  # m/s
magnetic_field = 0.1  # T
magnetic_force = charge * velocity * magnetic_field
```

17. The magnetic flux through a loop of wire is given by: $$ \Phi = B A \cos(\theta) $$

```
magnetic_field = 0.1  # T
area = 0.01  # m^2
angle = 30  # degrees
magnetic_flux = magnetic_field * area * math.cos(math.radians(angle))
```

18. The inductance of a coil is given by: $$ L = \frac{\mu_0 N^2 A}{l} $$ where (\mu_0) is the permeability of free space.

```
N = 100  # number of turns
area = 0.01  # m^2
length = 0.1  # m
mu_0 = 4 * 3.14159e-7  # T m/A
inductance = (mu_0 * N ** 2 * area) / length
```

19. The energy stored in an inductor is given by: $$ E = \frac{1}{2} L I^2 $$

```
inductance = 0.01  # H
current = 2.0  # A
energy_stored = 0.5 * inductance * (current ** 2)
```

20. The resonant frequency of an LC circuit is given by: $$ f = \frac{1}{2\pi \sqrt{LC}} $$

```
L = 0.01  # H
C = 1e-6  # F
resonant_frequency = 1 / (2 * 3.14159 * (L * C) ** 0.5)
```

21. The pressure exerted by a fluid at a certain depth is given by: $$ P = \rho gh $$ where (\rho) is the density of the fluid.

```
density = 1000  # kg/m^3
depth = 10.0  # m
g = 9.8  # m/s^2
pressure = density * g * depth
```

22. The buoyant force on an object submerged in a fluid is given by: $$ F_b = \rho V g $$

```
density = 1000  # kg/m^3
volume = 0.01  # m^3
g = 9.8  # m/s^2
buoyant_force = density * volume * g
```

23. The flow rate of a fluid through a pipe is given by: $$ Q = A v $$

```
area = 0.01  # m^2
velocity = 2.0  # m/s
flow_rate = area * velocity
```

24. The heat transferred in a thermodynamic process is given by: $$ Q = mc\Delta T $$ where (c) is the specific heat capacity.

```
mass = 1.0  # kg
specific_heat = 4200  # J/(kg K)
temperature_change = 10  # K
heat_transferred = mass * specific_heat * temperature_change
```

25. The efficiency of a heat engine is given by: $$ \eta = \frac{W}{Q_H} $$

```
work_output = 100.0  # J
heat_input = 200.0  # J
efficiency = work_output / heat_input
```

26. The entropy change in a reversible process is given by: $$ \Delta S = \frac{Q}{T} $$

```
heat_transferred = 100.0  # J
temperature = 300.0  # K
entropy_change = heat_transferred / temperature
```

27. The wavelength of light is given by: $$ \lambda = \frac{c}{f} $$ where (c) is the speed of light.

```
frequency = 5e14  # Hz
speed_of_light = 3e8  # m/s
wavelength = speed_of_light / frequency
```

28. The energy of a photon is given by: $$ E = \frac{hc}{\lambda} $$ where (h) is Planck's constant.

```
wavelength = 500e-9  # m
h = 6.626e-34  # J s
speed_of_light = 3e8  # m/s
energy = h * speed_of_light / wavelength
```

29. The refractive index of a medium is given by: $$ n = \frac{c}{v} $$

```
speed_of_light = 3e8  # m/s
speed_in_medium = 2e8  # m/s
refractive_index = speed_of_light / speed_in_medium
```

30. The focal length of a lens is given by the lens formula: $$ \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} $$

```
object_distance = 10.0  # cm
image_distance = 20.0  # cm
focal_length = 1 / (1 / object_distance + 1 / image_distance)
```

Solutions for Additional Problems

31. To calculate the sum of the first 10 natural numbers:

```
sum_natural_numbers = sum(range(1, 11))
```

32. To determine the factorial of a given number:

```
number = 5
factorial = 1
for i in range(1, number + 1):
    factorial *= i
```

33. To find the sum of all even numbers between 1 and 20:

```
sum_even_numbers = sum(i for i in range(1, 21) if i % 2 == 0)
```

34. To calculate the average of a list of numbers:

```
numbers = [2, 4, 6, 8, 10]
average = sum(numbers) / len(numbers)
```

35. To determine the maximum value in a list of numbers:

```
numbers = [3, 1, 4, 1, 5, 9, 2, 6, 5]
max_value = max(numbers)
```

36. To find the number of occurrences of the number 3 in a list:

```
numbers = [3, 1, 4, 3, 5, 3, 2, 3, 5]
occurrences = numbers.count(3)
```

37. To calculate the sum of the squares of the first 5 natural numbers:

```
sum_squares = sum(i**2 for i in range(1, 6))
```

38. To determine the product of all odd numbers between 1 and 10:

```
product_odd_numbers = 1
for i in range(1, 11):
    if i % 2 != 0:
        product_odd_numbers *= i
```

39. To find the sum of all prime numbers less than 20:

```
def is_prime(n):
    if n <= 1:
        return False
    for i in range(2, int(n**0.5) + 1):
        if n % i == 0:
            return False
    return True

sum_primes = sum(i for i in range(2, 20) if is_prime(i))
```

40. To calculate the Fibonacci sequence up to the 10th term:

```
fibonacci_sequence = [0, 1]
for i in range(2, 10):
    next_term = fibonacci_sequence[-1] + fibonacci_sequence[-2]
    fibonacci_sequence.append(next_term)
```