RIT | Rochester Institute of Technology of Dubai

**The Physics Placement Exam covers a range of topics, including:**

1) Units Conversion and Significant Figures Rules
2) One-Dimensional Motion (Position, Displacement, Velocity, Speed and Acceleration)
3) Free Fall
4) Vectors
5) Two-Dimensional Motion – Projectile Motion
6) Newton's Laws
7) Friction Force
8) Uniform Circular Motion
9) Work, Kinetic Energy and Power
10) Work and Kinetic Energy Theorem
11) Potential Energy, and the Conservation Law of Mechanical Energy
12) Linear Momentum, Impulse, and Collisions
13) Electric Charge, Electric Force and Electric Field
14) Electric Potential and Electric Potential Energy
15) Capacitors
16) Current, Current Density, Resistivity, and Resistance
17) Ohm's Law
18) Magnetic Field and Magnetic Force on Point Charge (The Lorentz force)
19) Magnetic Force on a Wire Carrying Current
20) Magnetic Force between Two Parallel Wires
21) Geometric Optics, Reflection, Refraction, and Critical Angle
22) Curve Mirrors and Thin Lenses

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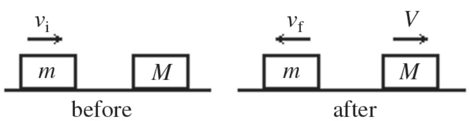
**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

1) A block of mass $m = 6.7$ kg, moving on a frictionless surface with a speed $v_i = 9.9$ m/s, makes a sudden perfectly elastic collision with a stationary block of mass $M$, as shown in the figure. Just after the collision, the 6.7–kg block recoils with a speed of $v_f = 2.2$ m/s.What is the speed $V$ of the other block? 1) ________




A) 7.7 m/s B) 12.1 m/s C) 11.0 m/s D) 8.8 m/s E) 9.9 m/s

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2) A 6.0 μF and a 8.0 μF capacitor are connected in series across an 8.0–V DC source. What is the voltage across the 6.0 μF capacitor? 2) ________

A) 4.6 V B) 2.7 V C) 0 V D) 3.6 V E) 8.0 V

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3) What length of copper wire (resistivity $1.68 \times 10^{-8}$ Ω·m) of diameter 0.15 mm is needed for a total resistance of 15 Ω? 3) ________

A) 16 m B) 160 m C) 16 cm D) 1.6 m E) 16 mm

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4) What is the conversion factor between km/h and m/s? 4) ________

A) $7.72 \times 10^{-5}$ (m/s)/(km/h)
B) $2.78 \times 10^{-1}$ (m/s)/(km/h)
C) 16.7 (m/s)/(km/h)
D) 3.60 (m/s)/(km/h)
E) $1.30 \times 10^{4}$ (m/s)/(km/h)

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5) A +8.00−μC charge is situated along the +$y$−axis at $y$ = 0.400 m. What is the electric potential at the origin because of this charge? 5) ________

A) 0 V

B) $+180 \times 10^3$ V

C) $-180 \times 10^3$ V

D) $+288 \times 10^3$ V

E) $-288 \times 10^3$ V

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6) A 2−kg ball is moving with a constant speed of 5 m/s in a horizontal circle whose radius is 50 cm. What is the acceleration of the ball? 6) ________

A) 10 m/s$^2$ B) 20 m/s$^2$ C) 500 m/s$^2$ D) 50 m/s$^2$ E) 0 m/s$^2$

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7) A piece of plastic has a net charge of +2.00 μC. How many more protons than electrons does this piece of plastic have? 7) ________

A) $2.50 \times 10^{19}$

B) 0

C) $1.25 \times 10^{19}$

D) $1.25 \times 10^{13}$

E) $2.50 \times 10^{13}$

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8) Starting from rest, a 4.0−kg body reaches a speed of 8.0 m/s in 2.0 s. What is the net force acting on the body? 8) ________

A) 2.0 N B) 4.0 N C) 8.0 N D) 32 N E) 16 N

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9) Vector $\vec{A}$ has a magnitude 5.00 and points in a direction 30.0° clockwise from the negative $y$ axis. What are the $x$ and $y$ components of vector $\vec{A}$. 9) ________

A) $A_x = 4.33$ and $A_y = 2.50$

B) $A_x = -2.50$ and $A_y = -4.33$

C) $A_x = 4.33$ and $A_y = -2.50$

D) $A_x = 3.78$ and $A_y = 4.29$

E) $A_x = -2.50$ and $A_y = 4.33$

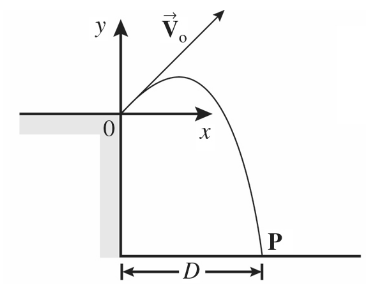
==========================================================================

10) A 1500–kg car accelerates from rest to 25 m/s in 7.0 s. What is the average power delivered by the engine? (1 hp = 746 W) 10) _______

A) 70 hp B) 80 hp C) 60 hp D) 90 hp

=================================================================

11) As shown in the figure, a projectile is fired at time $t = 0.00$ s, from point 0 at the upper edge of a cliff, with initial velocity components of $v_{0x} = 70$ m/s and $v_{0y} = 800$ m/s. The projectile rises and then falls into the sea at point P. The time of flight of the projectile is 200.0 s, and air resistance is negligible. At this location, $g = 9.80$ m/s$^2$. What is the horizontal distance $D$? 11) _______




A) 20,720 m B) 15,680 m C) 14,000 m D) 19,040 m E) 17,360 m

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12) When an object is 20 cm in front of a concave mirror, the image is 5.0 cm in front of the mirror? What is the focal length of the mirror? 12) _______

A) −2.1 cm B) 6.7 cm C) −0.25 cm D) 25 cm E) 4.0 cm

=================================================================

13) An object is thrown upwards with a speed of 12 m/s. How long does it take to reach a height of 3.0 m above the projection point while descending? 13) _______

A) 0.42 s B) 3.1 s C) 4.2 s D) 1.2 s E) 2.2 s

=================================================================

14) A charge Q = −5 μC is located at the origin. The electric field created by this charge at a point of coordinates (x = 0 m, y = 10 m) is equal to 14) _______

A) $(0.45 \times 10^3$ N/C$)\ \hat{i}$.

B) $(-0.45 \times 10^3$ N/C$)\ \hat{j}$.

C) $(-0.05 \times 10^3$ N/C$)\ \hat{j}$.

D) $(-0.45 \times 10^3$ N/C$)\ \hat{i}$.

E) $(-4.5 \times 10^9$ N/C$)\ \hat{j}$.

=================================================================

15) The force of attraction between a −35.0 μC and +101 μC charge is 4.00 N. What is the separation between these two charges? 15) _______

A) 2.10 m B) 2.82 m C) 2.49 m D) 3.67 m E) 1.13 m

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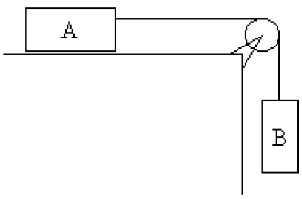
16) In the figure, block A has a mass of 2.60 kg. It rests on a smooth horizontal table and is connected by a very light horizontal string over an ideal pulley to block B, which has a mass of 1.60 kg. When block B is gently released from rest, how long does it take block B to travel 80.0 cm? 16) _______




A) 0.494 s B) 0.404 s C) 0.785 s D) 0.654 s E) 0.935 s

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17) What is the minimum energy needed to change the speed of a 1600−kg sport utility vehicle from 15.0 m/s to 40.0 m/s? 17) _______

A) 20.0 kJ B) 40.0 kJ C) 0.960 MJ D) 1.10 MJ E) 10.0 kJ

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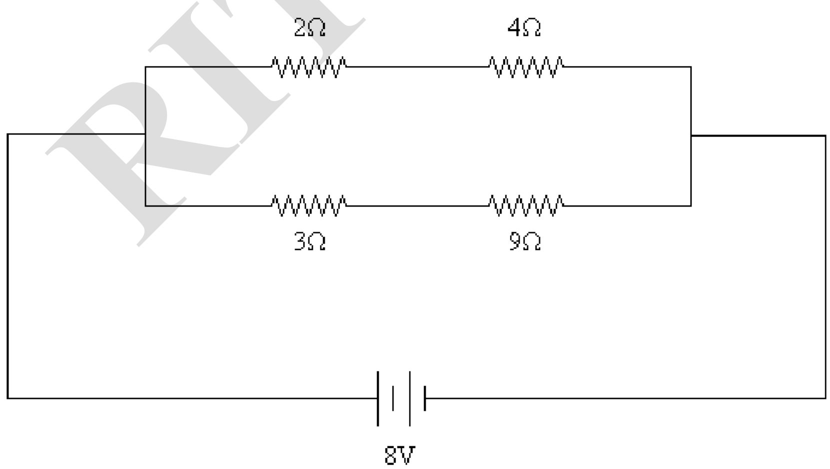
**FIGURE 1**




18) Four resistors of values 2 Ω, 4 Ω, 3 Ω, and 9 Ω are connected across an 8−V DC source as shown in Fig. 1. What is the current through the 9−Ω resistor? 18) _______

A) 0.9 A B) 2 A C) 0.7 A D) 0.5 A E) 1 A

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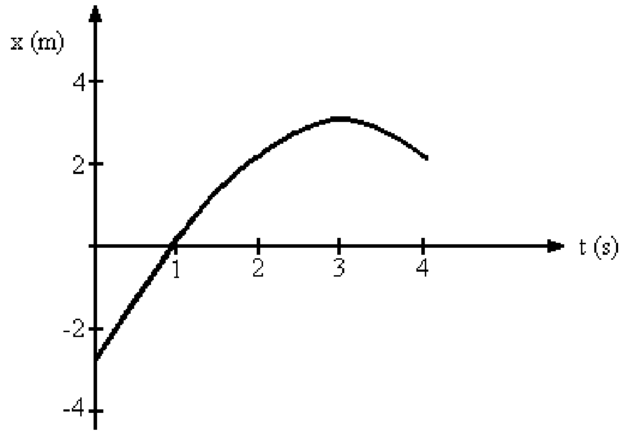
**FIGURE 1**




19) Fig. 1 represents the position of a particle as it travels along the $x$−axis. What is the average speed of the particle between t = 1 s and t = 4 s? 19) _______

A) 1.0 m/s B) 1.3 m/s C) 0.25 m/s D) 0.67 m/s E) 0.50 m/s

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20) An electron moving perpendicular to a uniform magnetic field of $3.2 \times 10^{-2}$ T moves in a circle of radius 0.40 cm. How fast is this electron moving? ($m_{el} = 9.11 \times 10^{-31}$ kg, $e = 1.60 \times 10^{-19}$ C) 20) _______

A) $1.9 \times 10^{-2}$ m/s

B) $8.0 \times 10^{6}$ m/s

C) $2.2 \times 10^{7}$ m/s

D) $3.0 \times 10^{6}$ m/s

E) $1.9 \times 10^{-30}$ m/s

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21) What is the critical angle for light traveling from crown glass ($n$ = 1.52) into water ($n$ = 1.33)? 21) _______

A) 57° B) 53° C) 61° D) 48° E) 42°

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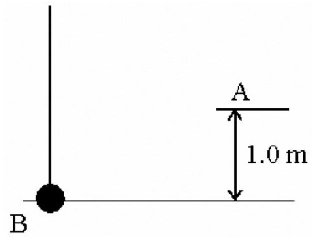
22) In the figure, a ball hangs by a very light string. What is the minimum speed of the ball at the bottom of its swing (point B) in order for it to reach point A, which is 1.0 m above the bottom of the swing? 22) ________




A) 4.9 m/s B) 3.1 m/s C) 4.4 m/s D) 2.2 m/s

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23) What is the product of 13.95 and 2.83 expressed to the correct number of significant figures? 23) ________

A) 39.48 B) 39 C) 39.479 D) 39.5

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24) A car is traveling with a constant speed when the driver suddenly applies the brakes, giving the car a deceleration of 3.50 $m/s^2$. If the car comes to a stop in a distance of 30.0 m, what was the car's original speed? 24) ________

A) 14.5 m/s B) 315 m/s C) 105 m/s D) 210 m/s E) 10.2 m/s

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25) During a hockey game, a puck is given an initial speed of 10 m/s. It slides 50 m on the horizontal ice before it stops due to friction. What is the coefficient of kinetic friction between the puck and the ice? 25) ________

A) 0.090 B) 0.10 C) 0.12 D) 0.11

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Answer Key
Testname: PHYSICS PLACEMENT EXAM SAMPLE VERSION1

1) A
2) A
3) A
4) B
5) B
6) D
7) D
8) E
9) B
10) D
11) C
12) E
13) E
14) B
15) B
16) D
17) D
18) C
19) B
20) C
21) C
22) C
23) D
24) A
25) B

# Physics Placement Exam Formula Sheet

## Kinematics in One Dimension

**Displacement** $\Delta x = x_2 - x_1 \quad (x_1 \equiv x(t_1),\ x_2 \equiv x(t_2))$

Average velocity $\bar{v}_x = \dfrac{\Delta x}{\Delta t}$

**Distance** $\ell = |\Delta x|$

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time elapsed}}$$

Average acceleration $\bar{a}_x = \dfrac{\Delta v_x}{\Delta t}$

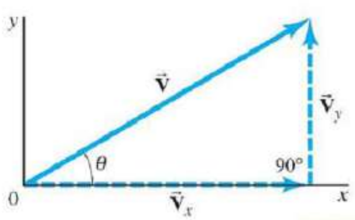
## Motion at Constant Acceleration

$$v = v_0 + at$$
$$x = x_0 + v_0 t + \tfrac{1}{2}at^2$$
$$v^2 = v_0^2 + 2a(x - x_0)$$

## Freely Falling Objects

$$v_y(t) = v_{y0} - gt$$
$$y(t) = y_0 + v_{y0}t - \tfrac{1}{2}gt^2$$
$$v_y(t)^2 - v_{y0}^2 = -2g[y(t) - y_0]$$

## Vectors by Components

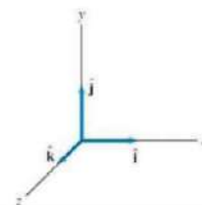



$$\sin\theta = \frac{V_y}{V}$$
$$\cos\theta = \frac{V_x}{V}$$
$$\tan\theta = \frac{V_y}{V_x}$$
$$V^2 = V_x^2 + V_y^2$$

$V = \sqrt{V_x^2 + V_y^2}$ and $\tan\theta = \dfrac{V_y}{V_x}$

## Unit Vectors

$$\vec{\mathbf{V}} = V_x\hat{\mathbf{i}} + V_y\hat{\mathbf{j}} + V_z\hat{\mathbf{k}}.$$




## Equations for Ideal Projectile Motion

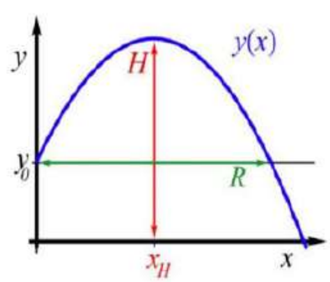
Acceleration (to be explained later) $\vec{a} = \vec{g}$

Acceleration along each axis: $\begin{cases} a_x(t) = 0 \\ a_y(t) = -g \end{cases}$

Horizontal motion: constant velocity
$$v_x(t) = v_{x0}$$
$$x(t) = x_0 + v_{x0}t$$

Vertical motion: free fall
$$v_y(t) = v_{y0} - gt$$
$$y(t) = y_0 + v_{y0}t - \tfrac{1}{2}gt^2$$

Use notation convention: $v_{x0} \equiv v_x(t=0)$; $\quad v_{y0} \equiv v_y(t=0)$




$$H = y_0 + \frac{v_{y0}^2}{2g}$$

$$R = \frac{v_0^2}{g}\sin 2\theta_0$$

Physics Placement Exam Formula Sheet

### Net Force

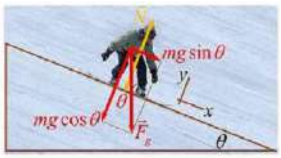
$$\vec{F}_{net} = \sum_{i=1}^{n} \vec{F}_i = \vec{F}_1 + \vec{F}_2 + ... + \vec{F}_n$$

$$F_{net,x} = \sum_{i=1}^{n} F_{i,x} = F_{1,x} + F_{2,x} + ... + F_{n,x}$$

$$F_{net,y} = \sum_{i=1}^{n} F_{i,y} = F_{1,y} + F_{2,y} + ... + F_{n,y}$$

$$F_{net,z} = \sum_{i=1}^{n} F_{i,z} = F_{1,z} + F_{2,z} + ... + F_{n,z}$$

$$a_x = g\sin\theta$$



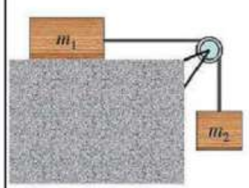

### Newton's Three Laws

- Newton's First Law:
  - In the absence of an external force on an object, this object will remain at rest, if it was at rest, or, if it was moving, it will remain in motion with the same velocity.
- Newton's Second Law:
  - If there is a net external force $\vec{F}_{net}$ acting on an object with mass , then the force will cause an acceleration, $\vec{a}$ :

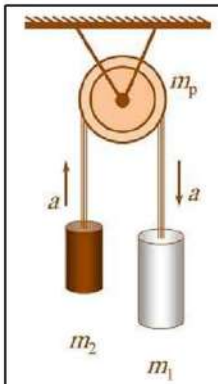
$$\vec{F}_{net} = m\vec{a}$$

- Newton's Third Law:
  - The forces that two interacting objects exert on each other are always exactly equal in magnitude and opposite in direction to each other.

$$\vec{F}_{1,2} = -\vec{F}_{2,1}$$




$$a = g\frac{m_2}{m_1 + m_2}$$

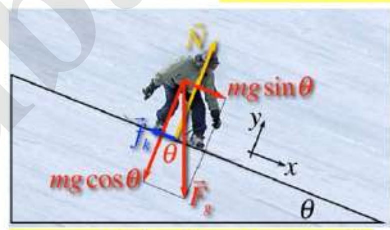



$$a = g\frac{m_1 - m_2}{m_1 + m_2}$$

### Friction

Kinetic Friction $f_k = \mu_k N$

Static Friction $f_s \le \mu_s N = f_{s,\max}$




$$a_x = g(\sin\theta - \mu_k \cos\theta)$$

### Uniform Circular Motion

$$\Sigma F_R = ma_R = m\frac{v^2}{r}$$

### Kinetic Energy $K = \frac{1}{2}mv^2$

### Work done by a constant force

$$W = \vec{F} \bullet \Delta\vec{r} = |\vec{F}||\Delta\vec{r}|\cos\alpha_{F\Delta r}$$

### One-Dimensional

$$W = F \cdot \Delta x = F \cdot (x - x_0)$$

### Average power

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

### Potential Energy

Gravity $U_g(y) = mgy$

Spring force $U_s(x) = \frac{1}{2}kx^2$

### Work-Kinetic Energy Theorem

$$\Delta K \equiv K - K_0 = W$$

### Spring Force

*F = -kx*

(for spring force)

$$W = -\frac{1}{2}kx^2 + \frac{1}{2}kx_0^2$$

Physics Placement Exam Formula Sheet

## Mechanical Energy

$$E = K + U$$

## Conservation of Energy

$$\Delta E = \Delta K + \Delta U = 0$$

$$K + U = K_0 + U_0$$

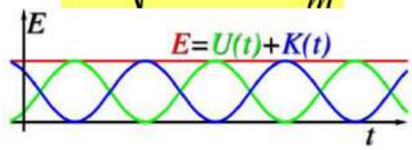
## Energy Conservation, Mass on Spring

$$U_s = \tfrac{1}{2} kx^2$$

$$E = \tfrac{1}{2} kA^2$$

$$\tfrac{1}{2} kA^2 = \tfrac{1}{2} mv^2 + \tfrac{1}{2} kx^2$$

$$v = \sqrt{(A^2 - x^2)\frac{k}{m}}$$




## Linear Momentum

$$\vec{p} = m\vec{v}$$

$$\vec{F} = \frac{d\vec{p}}{dt} \qquad K = \frac{p^2}{2m}$$

## Totally Inelastic Collisions

$$\vec{v}_{f,1} = \vec{v}_{f,2} \equiv \vec{v}_f$$

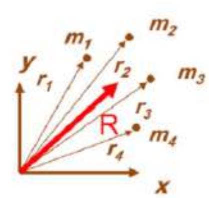
$$\vec{v}_f = \frac{m_1\vec{v}_{i,1} + m_2\vec{v}_{i,2}}{m_1 + m_2}$$

## Momentum Conservation in Collisions

$$\vec{p}_{f,1} + \vec{p}_{f,2} = \vec{p}_{i,1} + \vec{p}_{i,2}$$

## Center of Mass of a System of Masses

$$\vec{R} = \frac{\vec{r}_1 m_1 + \vec{r}_2 m_2 + \ldots + \vec{r}_n m_n}{m_1 + m_2 \ldots + m_n} = \frac{\sum_{i=1}^{n} \vec{r}_i m_i}{\sum_{i=1}^{n} m_i} = \frac{1}{M}\sum_{i=1}^{n} \vec{r}_i m_i$$




$m_i$ is the mass of the $i^{th}$ mass

$\vec{r}_i$ is the location of the $i^{th}$ mass

$\vec{R}$ is the location of the center of gravity of the system

$$M = \sum_{i=1}^{n} m_i$$

$$X = \frac{1}{M}\sum_{i=1}^{n} x_i m_i; \quad Y = \frac{1}{M}\sum_{i=1}^{n} y_i m_i; \quad Z = \frac{1}{M}\sum_{i=1}^{n} z_i m_i$$

## Totally Elastic Collisions in 1d

$$p_{f,1} + p_{f,2} = p_{i,1} + p_{i,2}$$

$$\frac{p_{f,1}^2}{2m_1} + \frac{p_{f,2}^2}{2m_2} = \frac{p_{i,1}^2}{2m_1} + \frac{p_{i,2}^2}{2m_2}$$

$$p_{f,1} = \frac{m_1 - m_2}{m_1 + m_2} p_{i,1} + \frac{2m_1}{m_1 + m_2} p_{i,2}$$

$$p_{f,2} = \frac{2m_2}{m_1 + m_2} p_{i,1} + \frac{m_2 - m_1}{m_1 + m_2} p_{i,2}$$

$$v_{f,1} = \frac{m_1 - m_2}{m_1 + m_2} v_{i,1} + \frac{2m_2}{m_1 + m_2} v_{i,2}$$

$$v_{f,2} = \frac{2m_1}{m_1 + m_2} v_{i,1} + \frac{m_2 - m_1}{m_1 + m_2} v_{i,2}$$

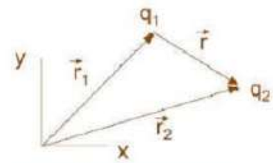
# Physics Placement Exam Formula Sheet

**Electric Force - Coulomb's Law**

$$F = \frac{kq_1q_2}{r^2}$$

$$k = 8.99\times10^9\ \text{Nm}^2/\text{C}^2$$

$$k = \frac{1}{4\pi\varepsilon_0}\quad \text{where}\quad \varepsilon_0 = 8.85\times10^{-12}\ \frac{\text{C}^2}{\text{Nm}^2}$$




$$\vec{r} = \vec{r}_2 - \vec{r}_1$$

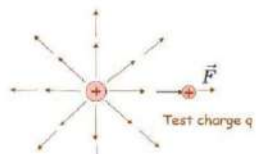
$$\hat{r} = \frac{\vec{r}}{r} = \frac{\vec{r}_2 - \vec{r}_1}{r}$$

$$\vec{F}_{12} = k\frac{q_1q_2}{r^2}\ \hat{r}$$

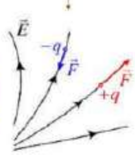
$$\vec{F}_{21} = k\frac{q_1q_2}{r^2}\ (-\hat{r})$$

**The Electric Field**

$$\vec{E} = \frac{\vec{F}}{q}$$




$$\vec{F} = q\vec{E}(\vec{x})$$




**Field of a point charge**

$$\vec{E}(\vec{x}) = \frac{\vec{F}}{q_0} = k\frac{q}{r^2}\hat{r}$$

**Superposition of Electric Fields**

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \ldots + \vec{E}_n$$

**Electric Potential of a Point Charge**

$$V(r) = \frac{kq}{r}$$

**Electric Potential from a System of Charges**

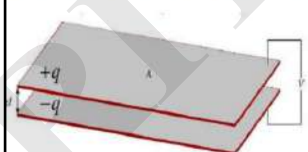
$$V = \sum_{i=1}^{n} V_i = \sum_{i=1}^{n}\frac{kq_i}{r_i}$$

**Capacitance**

$$q = CV$$

$$C = q/V$$

**Parallel Plate Capacitor**




$$C = \frac{\varepsilon_0 A}{d}$$

**Electric Potential Energy for a Pair of Particles**

$$U = q_2V_1(r) \qquad V_1(r) = \frac{kq_1}{r}$$

$$U = \frac{kq_1q_2}{r}$$

**Energy Stored in Capacitors**

$$U = \frac{1}{2}\frac{q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}qV$$

**Capacitors in Series**

$$\frac{1}{C_{eq}} = \sum_{i=1}^{n}\frac{1}{C_i}$$

**Capacitors in Parallel**

$$C_{eq} = \sum_{i=1}^{n} C_i$$

Physics Placement Exam Formula Sheet

## CURRENT

Current Density: $[A/m^2]$

$$i = JA$$

$$J = (ne)V_d$$

$$R = \frac{V}{i}$$

$i$ = current $[A]$
$J$ = current density $[A/m^2]$
$A$ = area $[m^2]$
$L$ = length of conductor $[m]$
$e$ = charge per carrier
$ne$ = carrier charge density $[C/m^3]$
$V_d$ = drift speed $[m/s]$

Resistivity: [Ohm Meters]

$$\rho = \frac{E}{J}$$

$$\rho = \frac{RA}{L}$$

$\rho$ = resistivity $[\Omega \cdot m]$
$E$ = electric field $[N/C]$
$J$ = current density $[A/m^2]$
$R$ = resistance $[\Omega$ ohms$]$
$A$ = area $[m^2]$
$L$ = length of conductor $[m]$

$$R = \rho \frac{L}{A}$$

### Resistors in Series

$$R_{eq} = \sum_{i=1}^{n} R_i$$

### Resistances in Parallel

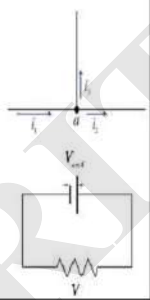
$$\frac{1}{R_{eq}} = \sum_{i=1}^{n} \frac{1}{R_i}$$

### power in electric circuits

$$P = iV = i^2 R = \frac{V^2}{R}$$

### Kirchhoff's Rules for Multi-loop Circuits

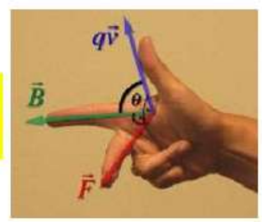
- To handle these types of circuits, we must apply Kirchhoff's Rules.
- Kirchhoff's Rules can be stated as
  - Kirchhoff's Junction Rule
    - The sum of the currents entering a junction must equal the sum of the currents leaving a junction
  - Kirchhoff's Loop Rule
    - The sum of voltage drops around a complete circuit loop must sum to zero



### Magnetic Force

$$\vec{F} = q\vec{v} \times \vec{B}(\vec{x})$$

$$F_B = qvB\sin\theta$$




### Particle Orbits in Uniform B

$$m\frac{v^2}{r} = qvB \qquad m\frac{v}{r} = qB \rightarrow \frac{p}{r} = qB$$

the period of revolution

$$T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$$

$$r = \frac{mv}{qB}$$

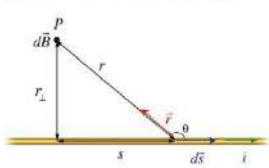
angular frequency

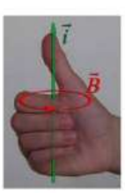
$$\omega = 2\pi f = \frac{qB}{m}$$

frequency

$$f = \frac{1}{T} = \frac{qB}{2\pi m}$$

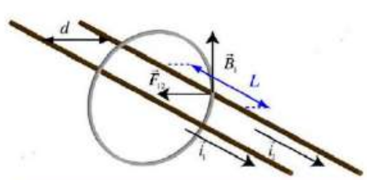
### Magnetic Field from a Long, Straight Wire





$$B(r_\perp) = \frac{\mu_0 i}{2\pi r_\perp}$$

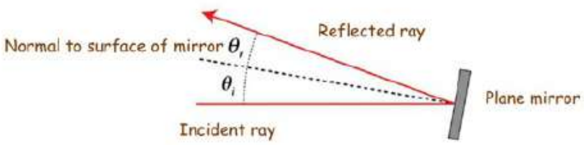
### Parallel Current Carrying Wires



$$F_{12} = i_2 L\left(\frac{\mu_0 i_1}{2\pi d}\right) = \frac{\mu_0 i_1 i_2 L}{2\pi d}$$

Physics Placement Exam Formula Sheet

## Reflection and Plane Mirrors




$$\theta_r = \theta_i$$

## Refraction

**Indices of Refraction:**

| | |
|---|---|
| Quartz: | 1.458 |
| Glass, crown | 1.52 |
| Glass, flint | 1.66 |
| Water | 1.333 |
| Air | 1.000 293 |

Angle of Incidence: The angle measured from the perpendicular to the face or from the perpendicular to the tangent to the face

Index of Refraction: Materials of greater density have a higher index of refraction.

$$n \equiv \frac{c}{v}$$

$n$ = index of refraction
$c$ = speed of light in a vacuum 3 × $10^8$ *m/s*
$v$ = speed of light in the material [*m/s*]

$$n = \frac{\lambda_0}{\lambda_n}$$

$\lambda_0$ = wavelength of the light in a vacuum [*m*]
$\lambda_v$ = its wavelength in the material [*m*]

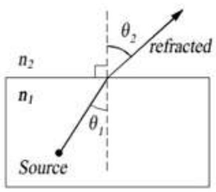
Law of Refraction: **Snell's Law**

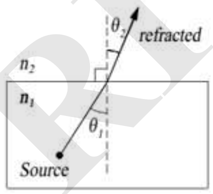
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$n$ = index of refraction
$\theta$ = angle of incidence

traveling to a region of lesser density: $\theta_2 > \theta_1$

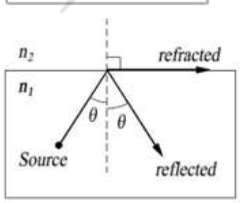
traveling to a region of greater density: $\theta_2 < \theta_1$




Critical Angle: The maximum angle of incidence for which light can move from $n_1$ to $n_2$

$$\sin\theta_c = \frac{n_2}{n_1} \quad \text{for } n_1 > n_2$$




## Spherical Mirrors

### Mirror Equation

Using these sign conventions we can express the mirror equation in terms of the object distance, $d_o$, and the image distance, $d_i$, and the focal length $f$ of the mirror

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

The magnification m of the mirror is defined to be

$$m = -\frac{d_i}{d_o} = \frac{h_i}{h_o}$$

the focal length, $f$, of a spherical mirror is

$$f = \frac{R}{2}$$

$R$ radius of the mirror

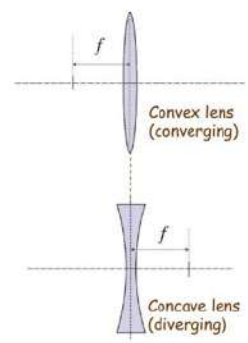
**Concave mirror has positive focal length**

**Convex mirror has negative focal length**

## Thin Lenses

The focal length of a convex (converging) defined to be positive

The focal length of a concave (diverging) defined to be negative




Lens Maker's Equation:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

### The Lens Equation

The images formed by lenses are described by the lens equation

$$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f}$$

### Magnification for Lenses

The magnification $m$ of a lens is defined the same as as for a mirror

$$m = -\frac{d_i}{d_o} = \frac{h_i}{h_o}$$

- $d_o$ is the object distance
- $h_o$ is the object height
- $d_i$ is the image distance
- $h_i$ is the image height