

Physics 110 Formula Sheet

Vectors

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

$$\phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$$

Motion Definitions

Displacement: $\Delta x = x_f - x_i$

Average velocity: $v_{avg} = \frac{\Delta x}{\Delta t}$

Average acceleration: $a_{avg} = \frac{\Delta v}{\Delta t}$

Equations of Motion

displacement:
$$\begin{cases} x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 \\ y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 \end{cases}$$

velocity:
$$\begin{cases} v_{fx} = v_{ix} + a_x t \\ v_{fy} = v_{iy} + a_y t \end{cases}$$

time-independent:
$$\begin{cases} v_{fx}^2 = v_{ix}^2 + 2a_x \Delta x \\ v_{fy}^2 = v_{iy}^2 + 2a_y \Delta y \end{cases}$$

Rotational Motion Definitions

Angular displacement: $\Delta s = R\Delta\theta$

Angular velocity: $\omega = \frac{\Delta\theta}{\Delta t} \rightarrow v = R\omega$

Angular acceleration: $\alpha = \frac{\Delta\omega}{\Delta t} \rightarrow \begin{cases} a_t = r\alpha \\ a_c = r\omega^2 \end{cases}$

Rotational Equations of Motion

$$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$$

Fluids

$$\rho = \frac{m}{V} \quad P = \frac{F}{A}$$

$$P_y = P_{air} + \rho g y$$

$$F_B = \rho g V$$

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2; \text{ compressible}$$

$$A_1 v_1 = A_2 v_2; \text{ incompressible}$$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

Momentum & Force

$$\vec{p} = m\vec{v} \rightarrow p_x = mv_x; p_y = mv_y$$

$$\Delta\vec{p} = \vec{F}\Delta t \rightarrow \vec{p}_f = \vec{p}_i + \vec{F}\Delta t$$

$$\vec{F} = \frac{d\vec{p}}{dt} = m\vec{a} \rightarrow F_x = ma_x; F_y = ma_y$$

$$F_{fr} = \mu F_N$$

$$F_w = mg$$

$$\text{stress} = E \times \text{strain} \rightarrow \frac{F}{A} = E \frac{\Delta l}{l} \rightarrow F_s = -kx$$

$$F_G = G \frac{M_1 M_2}{r^2}$$

$$F_c = ma_c = m \frac{v^2}{R}$$

Work & Energy

$$\begin{cases} W_T = \int \vec{F} \cdot d\vec{r} = F\Delta r \cos\theta = \Delta K_T \\ W_R = \int \vec{\tau} \cdot d\vec{\theta} = \tau\Delta\theta = \Delta K_R \end{cases}$$

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$$W_{net} = W_T + W_R = \Delta K_T + \Delta K_R = -\Delta U$$

$$K_T = \frac{1}{2}mv^2$$

$$K_R = \frac{1}{2}I\omega^2$$

$$U_g = mgy$$

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

$$\Delta E = \Delta E_R + \Delta E_T$$

$$\Delta E = \Delta K_R + \Delta K_T + \Delta U_g + \Delta U_s = \begin{cases} 0 \\ W_{fr} \end{cases}$$

Rotational Momentum & Force

$$\vec{\tau} = \vec{r} \times \vec{F}; \tau = r_{\perp} F = rF_{\perp} = rF \sin\theta$$

$$\tau = \frac{\Delta L}{\Delta t} = I\alpha$$

$$L = I\omega$$

$$\Delta\vec{L} = \vec{\tau}\Delta t \rightarrow \vec{L}_f = \vec{L}_i + \vec{\tau}\Delta t$$

Sound

$$v_s = f\lambda = (331 + 0.6T) \frac{m}{s}$$

$$\beta = 10 \log \frac{I}{I_0}$$

$$f_n = n f_1 = n \frac{v}{2L}; n = 1, 2, 3, \dots \text{ open pipes}$$

$$f_n = n f_1 = n \frac{v}{4L}; n = 1, 3, 5, \dots \text{ closed pipes}$$

Waves

$$v = f\lambda = \sqrt{\frac{F_T}{\mu}}$$

$$f_n = n f_1 = n \frac{v}{2L}; \quad n = 1, 2, 3, \dots$$

$$I = 2\pi^2 f^2 \rho v A^2$$

Common Metric Units

$$\text{nano (n)} = 10^{-9} \quad \text{centi (c)} = 10^{-2}$$

$$\text{micro (\mu)} = 10^{-6} \quad \text{kilo (k)} = 10^3$$

$$\text{milli (m)} = 10^{-3} \quad \text{mega (M)} = 10^6$$

Geometry/Algebra

Circles: $A = \pi r^2 \quad C = 2\pi r = \pi D$

Spheres: $A = 4\pi r^2 \quad V = \frac{4}{3}\pi r^3$

Triangles: $A = \frac{1}{2}bh$

Quadratics: $ax^2 + bx + c = 0 \rightarrow x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Simple Harmonic Motion

$$\omega = 2\pi f = \frac{2\pi}{T}$$

$$T_s = 2\pi \sqrt{\frac{m}{k}}; \quad \omega = \sqrt{\frac{k}{m}}$$

$$T_p = 2\pi \sqrt{\frac{l}{g}}; \quad \omega = \sqrt{\frac{g}{l}}$$

Equations of Motion for SHM

$$x(t) = \begin{cases} x_{max} \sin\left(\frac{2\pi}{T}t\right) \\ x_{max} \cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$v(t) = \begin{cases} v_{max} \cos\left(\frac{2\pi}{T}t\right) \\ -v_{max} \sin\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$a(t) = \begin{cases} -a_{max} \sin\left(\frac{2\pi}{T}t\right) \\ -a_{max} \cos\left(\frac{2\pi}{T}t\right) \end{cases}$$

$$v = \pm v_{max} \sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$$

$$v = \pm \omega x_{max} \sqrt{1 - \left(\frac{x}{x_{max}}\right)^2}$$

PERIODIC TABLE OF ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																																																												
1 H Hydrogen 1.008	2 He Helium 4.0026																																																																												
3 Li Lithium 6.94	4 Be Beryllium 9.0122											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180																																																												
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948																																																												
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798																																																												
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29																																																												
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	74 W Tungsten 183.84	75 Re Rhenium 186.21	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.97	80 Hg Mercury 200.59	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)																																																												
87 Fr Francium (223)	88 Ra Radium (226)	89-103 Actinoids	104 Rf Rutherfordium (261)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (271)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (290)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)																																																												
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.																																																																													
<table border="1"> <thead> <tr> <th>57</th><th>58</th><th>59</th><th>60</th><th>61</th><th>62</th><th>63</th><th>64</th><th>65</th><th>66</th><th>67</th><th>68</th><th>69</th><th>70</th><th>71</th> </tr> </thead> <tbody> <tr> <td>La Lanthanum 138.91</td> <td>Ce Cerium 140.12</td> <td>Pr Praseodymium 140.91</td> <td>Nd Neodymium 144.24</td> <td>Pm Promethium (145)</td> <td>Sm Samarium 150.36</td> <td>Eu Europium 151.96</td> <td>Gd Gadolinium 157.25</td> <td>Tb Terbium 158.93</td> <td>Dy Dysprosium 162.50</td> <td>Ho Holmium 164.93</td> <td>Er Erbium 167.26</td> <td>Tm Thulium 168.93</td> <td>Yb Ytterbium 173.05</td> <td>Lu Lutetium 174.97</td> </tr> <tr> <td>89</td><td>90</td><td>91</td><td>92</td><td>93</td><td>94</td><td>95</td><td>96</td><td>97</td><td>98</td><td>99</td><td>100</td><td>101</td><td>102</td><td>103</td> </tr> <tr> <td>Ac Actinium (227)</td> <td>Th Thorium 232.04</td> <td>Pa Protactinium 231.04</td> <td>U Uranium 238.03</td> <td>Np Neptunium (237)</td> <td>Pu Plutonium (244)</td> <td>Am Americium (243)</td> <td>Cm Curium (247)</td> <td>Bk Berkelium (247)</td> <td>Cf Californium (251)</td> <td>Es Einsteinium (252)</td> <td>Fm Fermium (257)</td> <td>Md Mendelevium (258)</td> <td>No Nobelium (259)</td> <td>Lr Lawrencium (260)</td> </tr> </tbody> </table>																		57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	La Lanthanum 138.91	Ce Cerium 140.12	Pr Praseodymium 140.91	Nd Neodymium 144.24	Pm Promethium (145)	Sm Samarium 150.36	Eu Europium 151.96	Gd Gadolinium 157.25	Tb Terbium 158.93	Dy Dysprosium 162.50	Ho Holmium 164.93	Er Erbium 167.26	Tm Thulium 168.93	Yb Ytterbium 173.05	Lu Lutetium 174.97	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	Ac Actinium (227)	Th Thorium 232.04	Pa Protactinium 231.04	U Uranium 238.03	Np Neptunium (237)	Pu Plutonium (244)	Am Americium (243)	Cm Curium (247)	Bk Berkelium (247)	Cf Californium (251)	Es Einsteinium (252)	Fm Fermium (257)	Md Mendelevium (258)	No Nobelium (259)	Lr Lawrencium (260)
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Object	Location of axis	Moment of inertia
(a) Thin hoop, radius R	Through center	MR^2
(b) Thin hoop, radius R , width W	Through central diameter	$\frac{1}{2}MR^2 + \frac{1}{12}MW^2$
(c) Solid cylinder, radius R	Through center	$\frac{1}{2}MR^2$
(d) Hollow cylinder, inner radius R_1 , outer radius R_2	Through center	$\frac{1}{2}M(R_1^2 + R_2^2)$
(e) Uniform sphere, radius R	Through center	$\frac{2}{5}MR^2$
(f) Long uniform rod, length L	Through center	$\frac{1}{12}ML^2$
(g) Long uniform rod, length L	Through end	$\frac{1}{3}ML^2$
(h) Rectangular thin plate, length L , width W	Through center	$\frac{1}{12}M(L^2 + W^2)$

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