1. (b)
2. (b)
3. (c)
4. (b)
5. (a)
6. (a)
7. (b)
8. (d)
9. (c)
10. (d) $\frac{2}{3}T_1 + \frac{1}{3}T_3$

The given situation can be represented as shown

Work done by engine A is given as

$$W_A = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T}{T_1} \Rightarrow \frac{Q_2}{Q_1} = \frac{T}{T_1} .(1)$$

Also, work done by engine B is given as

$$W_B = 1 - \frac{Q_3}{\left(\frac{Q_2}{2}\right)} = 1 - \frac{T_3}{T} \Rightarrow \frac{2Q_3}{Q_2} = \frac{T_3}{T} \ldots$$

Now, it is given as

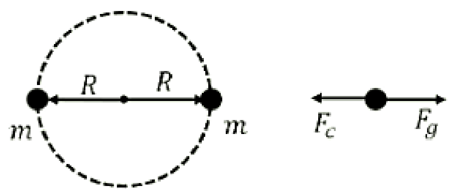
$$W_A = W_B$$
$$\Rightarrow Q_1 - Q_2 = \frac{Q_2}{2} - Q_3$$
$$\Rightarrow \frac{2Q_1}{Q_2} + \frac{2Q_3}{Q_2} = 3$$

From eq (1) and (2) we have

$$\Rightarrow \frac{2T_1}{T} + \frac{T_3}{T} = 3$$
$$\Rightarrow \frac{2T_1}{3} + \frac{T_3}{3} = T$$

11. (b)
12. (c)
13. (b) $\frac{1}{2}\sqrt{\frac{G}{R^3}}$

Due to mutual gravitational attraction, the particles will be at the position shown below.



From FBD we have

$$F_g = F_c$$
$$\Rightarrow \frac{Gm^2}{(2R)^2} = mR\omega^2$$
$$\Rightarrow \omega = \frac{1}{2}\sqrt{\frac{G}{R^3}}$$

14. (b)

(A) True, atom of each element emits characteristic spectrum.
(B) True, according to Bohr's Postulate, $\mathrm{mvr} = \frac{\mathrm{nh}}{2\pi}$ and hence electron resides into orbits of specific radius called stationary orbits.
(C) False, densityof nucleus is constant.
(D) False, a free neutron is unstable, decays into proton and electron and antineutrino.
(E) True, ustable nucleus shows radioactivity.

15. (b)

16. (c) Given, $y = m^2 r^{-4} g^x \Big| \frac{3}{2}$

As we know that, relative errors can be written as

$$\frac{\Delta y}{y} = \frac{2\Delta m}{m} + \frac{4\Delta r}{r} + \frac{x\Delta g}{g} + \frac{3\Delta l}{2l}$$

On multiplying each term by 100 , each term will represent percentage error.
So, putting the given values in the above equation we get,

$$18 = 2(1) + 4(0.5) + xp + \frac{3}{2}(4)$$
$$\Rightarrow 18 = 10 + xp$$
$$\Rightarrow 8 = xp$$

By trial and error, only option (c) is valid for this scenario. Thus, $x = \frac{16}{3} p = \pm\frac{3}{2}$

17. (d) Given, constant power is supplied. As we know

$$P = Fv = mav = mv\left(v\frac{dv}{dx}\right) = \frac{mv^2 dv}{dx}$$
$$\Rightarrow \int_0^x \frac{P}{m} dx = \int_0^v v^2 dv$$
$$\Rightarrow \frac{Px}{m} = \frac{v^3}{3}$$
$$\Rightarrow \left(\frac{3Px}{m}\right)^{\frac{1}{3}} = v$$

Also, we have

$$v=\frac{dx}{dt}$$

$$\Rightarrow\left(\frac{3p}{m}\right)^{\frac{1}{3}}\int_0^t dt=\int_0^x x^{-\frac{1}{3}}dx$$

$$\Rightarrow x=\left(\frac{8p}{9m}\right)^{\frac{1}{2}}\frac{3}{2}$$

Or, $x=\left[\sqrt{\left(\frac{8p}{9m}\right)}\right]t^{\frac{3}{2}}$

18. **(d)** Given, orbital radius, $r=9.0\times10^3$ km $=9\times10^6$ m

Time period of revolution, $T=7$ hours, 30 minutes $=2.7\times10^4$sec

Also, $\frac{4\pi^2}{\mathrm{G}}=6\times10^{11}\ \mathrm{N^{-1}\ m^{-2}\ kg^2}$

Let mass of Mars be M

We have from the formula of time period of revolution,

$$\mathrm{T}^2=\frac{4\pi^2}{\mathrm{GM}}\cdot\mathrm{r}^3$$

or, $M=\frac{4\pi^2}{G}\cdot\frac{r^3}{T^2}$

By putting values, we have

$$M=(6\times10^{11})\times\frac{(9\times10^6)^3}{(2.7\times10^4)^2}$$

$$\Rightarrow M=6\times10^{23}\ \mathrm{kg}$$

19. **(c)** From the given problem we can infer that

at $\mathrm{t}=0,\mathrm{u}=0$

also, $F=F_0\left[1-\left(\frac{t-T}{T}\right)^2\right]$

or, $F=F_0-\frac{F_0(t-T)^2}{T^2}$

Therefore, we have

acceleration, $a=\frac{F_0}{M}-\frac{F_0(t-T)^2}{MT^2}=\frac{dv}{dt}$

or, $\int_0^v dv=\int_{t=0}^{2T}\left(\frac{F_0}{M}-\frac{F_0(t-T)}{MT^2}\right)dt$

$$\Rightarrow v=\left[\frac{F_0}{M}\right]_0^{2T}-\frac{F_0}{MT^2}\left[\frac{t^3}{3}-t^2T+T^2t\right]_0^{2T}$$

$$\Rightarrow v=\frac{4F_0T}{3M}$$

The particle will have constant velocity, as force will not act after $t=2T$, which will be equal to v.

20. **(c)** As we know that

$R=R_0\big(1+a(\theta-\theta_0)\big)$, where, α is the temperature coefficient of resistance of the conductor.

Therefore, we have

$$16=R_0[1+a(15-\theta_0)]$$
$$20=R_0[1+a(100-\theta_0)]$$

Assuming
$\theta_0 = 0°\text{C}$, as a general convention.
Thus, we have

$$\frac{16}{20} = \frac{1 + a \times 15}{1 + a \times 100}$$
$$\Rightarrow 4(1 + 100a) = 5(1 + 15a)$$
$$\Rightarrow 325a = 1$$
$$\Rightarrow a = 0.003°\text{C}^{-1}$$

21. (9)

22. (2) Difference in number of wavelength is given as one
Let t be the thickness of the column.

$$\text{So, } \frac{\text{t}}{\lambda_{\text{air}}} - \frac{\text{t}}{\lambda_{\text{vaccum}}} = 1$$
$$\text{t}\left(\frac{1}{\lambda_{\text{air}}} - \frac{1}{\lambda_{\text{vaccum}}}\right) = 1$$
$$\frac{\text{t}}{\lambda_{\text{vaccum}}}(\mu_{\text{air}} - 1) = 1$$
$$\Rightarrow \text{t} = \frac{\lambda_{\text{vaccum}}}{(\mu_{\text{air}} - 1)} = \frac{6 \times 10^{-7}}{(1.0003 - 1)} = 2 \text{ mm}$$

23. (1) The modulation index is given by $\mu = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}}$ where $V_{\max}$ and $V_{\min}$ are maximum amplitude and minimum amplitude for an amplitude modulated wave respectively.

$$\therefore \mu = \frac{(12 - 3)}{(12 + 3)} = \frac{9}{15} = 0.6$$

Thus, value of x is 1.

24. (60)
25. (2)
26. (30)
27. (1)
28. (2)
29. (10)
30. (6)
31. (a)
32. (b)
33. (c)
34. (d)
35. (b)
36. (c)
37. (c)
38. (d)
39. (a)
40. (b)
41. (d)
42. (c)
43. (c)

44. (a)
45. (d)
46. (c)
47. (d)
48. (d)
49. (c)
50. (b)
51. (16)
52. (2)
53. (875)
54. (1575)
55. (10)
56. (6)
57. (125)
58. (60)
59. (300)
60. (28)
61. (b)
62. (d)
63. (d)
64. (c)
65. (d)
66. (a)
67. (c)
68. (c)
69. (c)
70. (b)
71. (c)
72. (b)
73. (a)
74. (b)
75. (b)
76. (a)
77. (b)
78. (b)
79. (d)
80. (c)
81. (9)
82. (7)
83. (1)
84. (3)
85. (5)
86. (b)
87. (2)
88. (924)
89. (832)
90. (2020)