JEE Main Test-2018 (Physics)

1. It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is P_d; While for its similar collision with carbon nucleus at rest, fractional loss of energy is P_c. The values of P_d and P_c are respectively :

(1) (0, 0) **(2)** (0, 1)

(3) (.89, .28) **(4)** (.28, .89)

Sol. [3] Let u be the inithal speed of neutron and let m_N be its mass. Then mass of deutron can be taken as $2m_N$ and of carbon as 12 m_N.

Now after collision.

$$\neg_{deutron} = \frac{2(m_N)}{m_N + (2m_N)} u = \frac{2u}{3}$$

Hence fraction of neutrons energy transfered

$$P_d = \frac{1}{2} \frac{(2m_N)(2u/3)^2}{\frac{1}{2}(m_N)u^2} = \frac{8}{9} = 0.89$$

Similarly after collision,

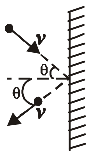
$$\neg_{deutron} = \frac{2(m_N)u}{m_N + 12m_N} = \frac{2u}{3}$$

& thus $P_c = \dfrac{1}{2} \dfrac{12m_N(2u/13)^2}{\frac{1}{2}m_N u^2} = \dfrac{48}{169} = 0.28$

2. The mass of hydrogen molecule is 3.32×10^{-27} kg. If 10^{23} hydrogen molecules strike, per second, a fixed wall of area 2 cm^2 at an angle of 45° to the normal, and rebound elastically with a speed of 10^3 m/s, then the pressure on the wall is nearly.

(1) 2.35×10^2 N / m^2 **(2)** 4.70×10^2 N / m^2

(3) 2.35×10^3 N / m^2 **(4)** 4.70×10^3 N / m^2

Sol. [3] 

(Pressure) $p = \dfrac{F}{A} = \dfrac{(2mv\cos¯)n}{A} = \dfrac{2\times10^{23}\times3.32\times10^{-27}\times10^3}{2\times10^{-4}}\times\dfrac{1}{\sqrt{2}}$

$= 2.35\times10^3$ N/m^2

3. A solid sphere of radius r made of a soft material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area of floats on the surface of the liquid, covering entire cross section of cylindrical container. When a mass m is placed on the surface of the piston to compress the liquid, the fractional decrement in the radius of the sphere, $\left(\dfrac{dr}{r}\right)$, is :

(1) $\dfrac{mg}{3\,Ka}$ **(2)** $\dfrac{mg}{Ka}$

(3) $\dfrac{Ka}{mg}$ **(4)** $\dfrac{Ka}{3\,mg}$

Sol. [1] $K = -\dfrac{\Delta p}{\Delta V/V} = -\dfrac{(mg/A)}{3dr/r}$

so $\dfrac{dr}{r} = \dfrac{mg}{3kA}$

4. Two batteries with e.m.f. 12 V and 13 V are connected in parallel across a load resistor of 10 Ω. The internal resistances of the two batteries are 1 Ω and 2 Ω respectively. The voltage across the load lies between:

(1) 11.4 V and 11.5 V **(2)** 11.7 V and 11.8 V

(3) 11.6 V and 11.7 V **(4)** 11.5 V and 11.6 V

Sol. [4] $E_{eq} = \dfrac{¶_1 r_2 + ¶_2 r_1}{r_1 + r_2} = \dfrac{37}{2}$ V

$r_{eq} = \dfrac{r_1 r_2}{r_1 + r_2} = \dfrac{2}{3}\,\Omega$

$V_{load} = \dfrac{R}{R + r_{eq}}(¶_{eq}) = \left(\dfrac{10}{10 + 2/3}\right)\left(\dfrac{37}{3}\right) = 11.56$ V

so, $11.5V < V_{load} < 11.6$ V

5. A particle is moving in a circular path of radius a under the action of an attractive potential $U=-\frac{k}{2r^2}$. Its total energy is :

(1) zero **(2)** $-\frac{3}{2}\frac{k}{a^2}$

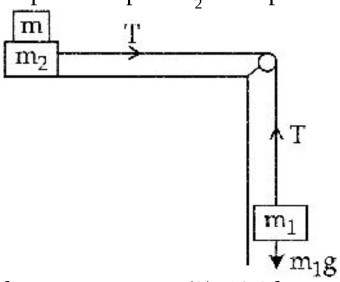
(3) $-\frac{k}{4a^2}$ **(4)** $\frac{k}{2a^2}$

Sol. [1] $F=-\frac{dU}{dr}=-\frac{k}{r^3}=-\frac{mv^2}{r}$

so, $K=\frac{1}{2}mv^2=\frac{K}{2r^2}$

$\therefore\ E=U+K=\text{zero}$

6. Two masses m_1 = 5 kg and m_2 = 10 kg, connected by an inextensible string over a frictionless pulley, are moving as shown in the figure. The coefficient of friction of horizontal surface is 0.15. The minimum weight m that should be put on top of m_2 to stop the motion is :



(1) 43.3 kg **(2)** 10.3 kg

(3) 18.3 kg **(4)** 27.3 kg

Sol. [4] $m_1 g < « (m+m_2)g$

or $m > \frac{m_1}{«} - m_2 = \frac{5}{0.15} - 10 = \frac{70}{3}$ kg

so $m_{min} = 27.3$ kg

7. If the series limit frequency of the Lyman series is $¬_L$, then the series limit frequency of the Pfund series is :

(1) $¬_L/16$ **(2)** $¬_L/25$

(3) $25¬_L$ **(4)** $16¬_L$

Sol. [2]

For lyman series $h¬_L = E_0$

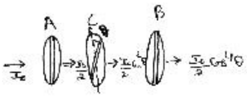
and for pfund series $h¬_F^0 = E_0/5^2$

$\therefore$ $¬_F = \frac{¬_L}{25}$

8. Unpolarized light of intensity I passes through an ideal polarizer A. Another identical polarizer B is placed behind A. The intensity of light beyond B is found to be $\frac{I}{2}$. Now another identical polarizer C is placed between A and B. The intensity beyond B is now found to be $\frac{I}{8}$. The angle between polarizer A and C is:

(1) 45° **(2)** 60°

(3) 0° **(4)** 30°

Sol. [1] 

$\frac{I'_o}{2}\cos^4 – = \frac{I_o}{8} \Rightarrow\ – = 45^o$

9. An electron from various excited states of hydrogen atom emit radiation to come to the ground state. Let a_n, a_g be the de Broglie wavelength of the electron in the n[th] state and the gound state respectively. Let Λ_n be the wavelength of the emitted photon in the transition from the n[th] state to the ground state. For large n, (A, B are constants)

(1) $\Lambda_n^2 \approx A + B a_n^2$ **(2)** $\Lambda_n^2 \approx a$

(3) $\Lambda_n \approx A + \frac{B}{a_n^2}$ **(4)** $\Lambda_n \approx A + B a_n$

Sol. [3] Here $(a_n)n = 2®(n^2 a_0)$ .....(i)

as $r_n = n^2 a_0$

where a_0 is Bohr radius

and $a_g = 2na_0$ .....(ii)

Hence $\frac{a_n}{a_g} = n$ .....(iii)

Also $\frac{1}{\Lambda_n} = R\left(1-\frac{1}{n^2}\right)$

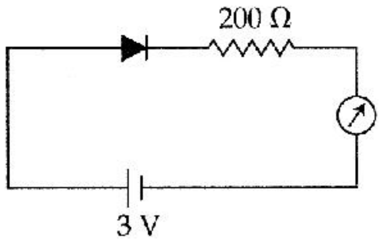
or $\Lambda_n = \frac{1}{R}\left(1-\frac{1}{n^2}\right)^{-1}$

$\Lambda_n \approx \frac{1}{R}\left(1+\frac{1}{n^2}\right)$ Since n >> 1

or $\Lambda_n \approx \frac{1}{R}\left(1+\frac{a_g^2}{a_n^2}\right)$

so $\Lambda_n = A + \frac{B}{a_n^2}$ is the correct option

10. The reading of the ammeter for a silicon diode in the given circuit is :



(1) 11.5 mA **(2)** 13.5 mA
(3) 0 **(4)** 15 mA

Sol. [1] Here silicon diode is given & under forward bias voltage drop across it will be 0.7 V.

Hence $i = \frac{(3-0.7)}{200} \text{A} = 11.5 \text{ mA}$

11. An electron, a proton and an alpha particle having the same kinetic energy are moving in circular orbits of radii r_e, r_p, r_α respectively in a uniform magnetic field B. The relation between r_e, r_p, r_α is :

(1) $r_e < r_p < r_\alpha$ **(2)** $r_e < r_\alpha < r_p$
(3) $r_e > r_p = r_\alpha$ **(4)** $r_e < r_p = r_\alpha$

Sol. [4] $r = \frac{\sqrt{2Km}}{qB} \propto \frac{\sqrt{m}}{q}$

$\because \; r_e : r_p : r_\alpha = \sqrt{m_e} : \sqrt{m_p} : \sqrt{m_p}$

$\Rightarrow \; r_e = r_p = r_\alpha$

12. A parallel plate capacitor of capacitance 90 pF is connected to a battery of emf 20 V. If a dielectric material of dielectric constant $K = \frac{5}{3}$ is inserted between the plates, the magnitude of the induced charge wll be :

(1) 2.4 n C **(2)** 0.9 n C
(3) 1.2 n C **(4)** 0.3 n C

Sol. [3] $Q_{in} = Q\left(1 - \frac{1}{K}\right) = C_o VK\left(1 - \frac{1}{K}\right)$

$= \left(90 \times 10^{-12}\right)(20)\left(\frac{5}{3} - 1\right)$

$= 1.2 nC$

13. For an RLC circuit driven with voltage of amplitude V_m and frequency $\omega_o = \frac{1}{\sqrt{LC}}$ the current exibits resonance. The quality factor, Q is given by :

(1) $\frac{R}{(\mu_o C)}$ **(2)** $\frac{CR}{\mu_o}$

(3) $\frac{\mu_o L}{R}$ **(4)** $\frac{\mu_o R}{L}$

Sol. [3]

14. A telephonic communication service is working at carrier frequency of 10 GHz. Only 10 % of its is utilized for transmission. How many telephonic channels can be transmitted simultaneously if each channel requires a bandwidth of 5 kHz?

(1) 2×10^5 **(2)** 2×10^6
(3) 2×10^3 **(4)** 2×10^4

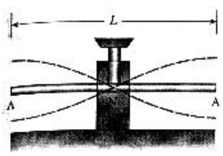
Sol. [1] Hence band width available is 1 GHz & hence number of channels transmitted

$N = \frac{1 \text{ GHz}}{5 \text{ kHz}} = \frac{10^9}{5 \times 10^3} = 2 \times 10^5$

15. A granite rod of 60 cm length is clamped at its middle point and is set into longitudinal vibrations. The density of granite is 2.7×10^3 kg / m^3 and its Young's modulus is 9.27×10^{10} Pa. What will be the fundamental frquency of the longitudinal vibrattions?

(1) 10 kHz **(2)** 7.5 kHz
(3) 5 kHz **(4)** 2.5 kHz

Sol. [3]



$L = \frac{\lambda}{2}$ so $\lambda = 2L$

$f = \frac{v}{\lambda} = \frac{\sqrt{Y/\rho}}{2L} = \frac{\sqrt{\frac{9.27 \times 10^{10}}{2.7 \times 10^3}}}{2(1.2)} = 2.5 kHz$

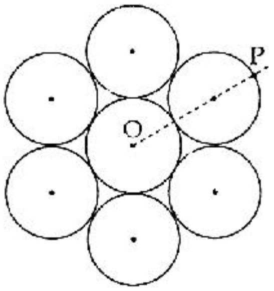
16. Seven identical circular planar disks, each of mass *M* and radius *R* are welded symmetrically as shown. The moment of inertia of the arrangement about the axis normal to the plane and passing through the point P is:

(1) $\frac{73}{2}MR^2$

(2) $\frac{181}{2}MR^2$

(3) $\frac{19}{2}MR^2$

(4) $\frac{55}{2}MR^2$



Sol. [2] $I_o = \frac{mR^2}{2} + 6\left[\frac{mR^2}{2} + m(2R)^2\right] = \frac{55}{2}mR^2$

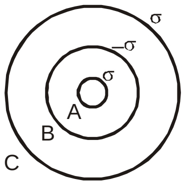
$I_p = I_o + 7m(3R)^2 = \left(\frac{55+63}{2}\right)mR^2 = \frac{|8|}{2}mR^2$

17. Three concentric metal shells A, B and C of respective radii a, b and c (a < b < c) have surface charge densities $+\sigma, -\sigma$ and $+\sigma$ respectively. The potential of shell B is :

(1) $\frac{\sigma}{\in_0}\left[\frac{b^2-c^2}{b}+a\right]$ **(2)** $\frac{\sigma}{\in_0}\left[\frac{b^2-c^2}{c}+a\right]$

(3) $\frac{\sigma}{\in_0}\left[\frac{a^2-b^2}{a}+c\right]$ **(4)** $\frac{\sigma}{\in_0}\left[\frac{a^2-b^2}{b}+c\right]$

Sol. [4]



$V(r=b) = \frac{1}{4®£_o}\left[\frac{\pm(4®a^2)}{b} + \frac{(-\pm)(4®b^2)}{b} + \frac{\pm(4®c^2)}{c}\right]$

$= \frac{\pm}{£_o}\left[\frac{a^2-b^2}{b}+c\right]$

18. In a potentiometer experiment, it is found that no current passes through the galvanometer when the terminals of the cell are connected across 52 cm of the potentiometer wire. If the cell is shunted by a resistance of $5\,\Omega$, a balance is found when the cell is connected across 40 cm of the wire. Find the internal resistance of the cell.

(1) $2\,\Omega$ **(2)** $2.5\,\Omega$

(3) $1\,\Omega$ **(4)** $1.5\,\Omega$

Sol. [4] Using the standard result

$$r = r_{ext}\left(\frac{l_{open}}{l_{closed}} - 1\right) = 5\Omega\left(\frac{52}{40} - 1\right) = 1.5\,\Omega.$$

19. An EM wave from air enters a medium. The electric fields are

$\vec{E}_1 = E_{01}\,\hat{x}\cos\left[2®¬\left(\frac{z}{c} - t\right)\right]$ in air and

$\vec{E}_2 = E_{02}\,\hat{x}\cos\left[k(2z - ct)\right]$ in medium, where the wave number k and frequency ν refer to their values in air. The medium is non-magnetic. If $\in_{r_1}$ and $\in_{r_2}$ refer to relative permittivities of air and medium respectively, which of the following options is correct?

(1) $\frac{\in_{r_1}}{\in_{r_2}} = \frac{1}{4}$ **(2)** $\frac{\in_{r_1}}{\in_{r_2}} = \frac{1}{2}$

(3) $\frac{\in_{r_1}}{\in_{r_2}} = 4$ **(4)** $\frac{\in_{r_1}}{\in_{r_2}} = 2$

Sol. [1] $C = \frac{1}{\sqrt{«_o£_o}}$ and $v = \frac{1}{\sqrt{«_o£_o£_r}}$

$\Rightarrow \frac{c}{v} = \sqrt{£_r}$

$v_{air} = c$ and $v_{med} = \frac{c}{2}$

$\therefore \frac{¶_{r_1}}{¶_{r_2}} = \frac{v_{med}^2}{v_{air}^2} = \frac{1}{4}$

20. The angular width of the central maximum in a single slit diffraction pattern is 60^o. The width of the slit is $1\,\mu m$. The slit is illuminated by monochromatic plane waves. If another slit of same width is made near it, Young's fringes can be observed on a screen placed at a distance 50 cm from the slits. If the observed fringe witdth is 1 cm, what is slit separation distance? (i.e., distance between the centres of each slit)

(1) $25\,\mu m$ **(2)** $50\,\mu m$

(3) $75\,\mu m$ **(4)** $100\,\mu m$

Sol. [1] $\frac{®}{3} = \frac{2ª}{a}$ . . . (i)

$10^{-2} = \frac{ªD}{d}$ . . . (ii)

$d = \left(\frac{100®}{3}\right)\frac{aD}{2} = \left(\frac{50®}{3}\right)(10^{-6})(0.5) \approx 25«m$

21. A siver atom in a solid oscillates in simple harmonic motion in some direction with a frequency of 10^{12} / sec. What is the force constant of the bonds connecting one atom with the other? (Mole wt. of silver = 108 and Avagadro number = 6.02×10^{23} gm mole^{-1})

(1) 2.2 N / m **(2)** 5.5 N / m

(3) 6.4 N / m **(4)** 7.1 N / m

Sol. [4] $f = \frac{1}{2®}\sqrt{\frac{k}{m}}$ so $k = 4®^2 f^2 m = 4 \times 10 \times 10^{24} \times \frac{108 \times 10^{-3}}{6.02 \times 10^{23}}$

$= 7.1\ \text{N/m}$

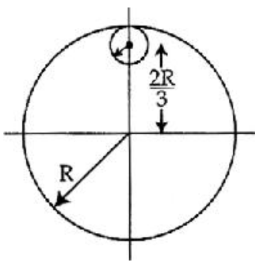
22. From a uniform circular disc of radius R and mass 9 M, a small disc of radius $\frac{R}{3}$ is removed as shown in the figure. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through centre of disc is :

(1) 10 MR^2

(2) $\frac{37}{9} MR^2$

(3) 4 MR^2

(4) $\frac{40}{9} MR^2$



Sol. [3] Let I_{RD} : MI of remaining disk

I_{CD} : MI of complete disk

I_{CO} : MI of cut out

$I_{RD} = -I_{CD} - I_{CO} \left[\frac{M_{CO}}{M_{CD}} = \frac{®(R/3)^2}{®R^2} = \frac{1}{9} \text{ so } M_{CO} = M \right]$

$= (9M)\frac{R^2}{2} - \left[\frac{MR^2/9}{2} + M\left(\frac{2R}{3}\right)^2 \right]$

$= 4MR^2$

23. In a collinear collision, a particle with an initial speed v_0 strikes a stationary particle of the same mass. If the final total kinetic energy is 50% greater than the original kinetic energy, the magnitude of the relative velocity between the two particles, after collision, is

(1) $\frac{v_0}{2}$ **(2)** $\frac{v_0}{\sqrt{2}}$

(3) $\frac{v_0}{4}$ **(4)** $\sqrt{2}\, v_0$

Sol. [4] $K_{cm} = \frac{1}{2}(m+m)\left(\frac{mv_o}{m+m}\right)^2 = \frac{1}{4}mv_o^2 = \frac{K_i}{2}$

$K_i = K_{cm} + \frac{1}{2}«u_{rel}^2 \Rightarrow \frac{1}{2}«u_{rel}^2 = \frac{K_i}{2}$

$k_f = 1.5k_i = k_{cm} + \frac{1}{2}«v_{rel}^2 \Rightarrow \frac{1}{2}mv_{rel}^2 = k_i$

so, $\frac{v_{rel}}{u_{rel}} = \sqrt{2}$

24. The dipole moment of a circular loop carrying a current I, is m and the magnetic field at the centre of the loop is B_1. When the dipole moment is doubled by keeping the current constant, the magnetic field at the centre of the loop is B_2. The ratio $\frac{B_1}{B_2}$ is :

(1) $\sqrt{2}$ **(2)** $\frac{1}{\sqrt{2}}$

(3) 2 **(4)** $\sqrt{3}$

Sol. [1] $B = \frac{«_0 ni}{2r}$ so $m = ni®r^2$

so $B \propto \frac{1}{\sqrt{m}} \Rightarrow \frac{B_1}{B_2} = \sqrt{2}$

25. The density of a material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively 1.5% and 1%, the maximum error in determining the dentisy is :

(1) 4.5 % **(2)** 6 %

(3) 2.5 % **(4)** 3.5 %

Sol. [1] $\left.\frac{\Delta°}{°}\right|_{max} \pm \left[3\left|\frac{\Delta L}{L}\right|_{max} + \left|\frac{\Delta m}{m}\right|_{max} \right]$

$= \pm[3(1\%) + 1.5\%]$

$= \pm 4.5\%$

26. On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of their series combination is 1 $k\Omega$. How much was the resistance on the left slot before interchanging the resistances?

(1) 550 Ω **(2)** 910 Ω

(3) 990 Ω **(4)** 505 Ω

Sol. [1] Let $\frac{R_1}{R_2} = \frac{x}{100 - x}$ .....(i)

then on interchanging

$\frac{R_2}{R_1} = \frac{x - 10}{100 - (x - 10)} = \frac{x - 10}{110 - x}$ .....(ii)

(Since it shift leftwards)

from (i) & (ii)

$$\frac{(x)(x-10)}{(100-x)(110-x)}=1$$

$$x^2-10x=11000-210x+x^2$$

or $x=55.$

so $\frac{R_1}{R_2}=\frac{55}{45}$ and $R_1+R_2=1000\,\Omega$

$\Rightarrow$ $R_1=550\,\Omega$ and $R_2=450\,\Omega.$

27. In an a.c. circuit, the instantaneous e.m.f. and current are given by

$e = 100\sin 30\,t$

$i = 20\sin\left(30\,t-\frac{\text{®}}{4}\right)$

In one cycle of a.c., the average power consumed by the circuit and the wattless current are, respectively :

(1) $\frac{50}{\sqrt{2}},0$ **(2)** 50, 0

(3) 50, 100 **(4)** $\frac{1000}{\sqrt{2}},10$

Sol. [4] $P_{av}=V_{rms}i_{rms}\cos\text{¤}=\frac{(100)(20)}{2}\times\frac{1}{\sqrt{2}}=\frac{1000}{\sqrt{2}}$

$i_{wattless}=i_{rms}\sin\text{¤}=\left(\frac{20}{\sqrt{2}}\right)\left(\frac{1}{\sqrt{2}}\right)=10$

28. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up.

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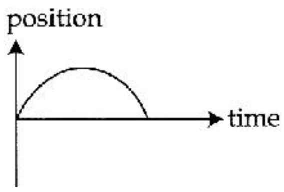

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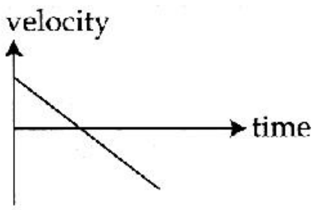

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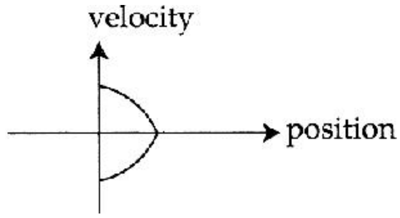

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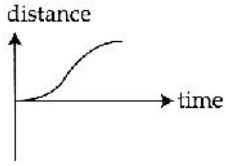

Sol. [4] Except in option (4),

in all the graphs, $a=\frac{dv}{dt}=V\frac{dv}{dx}=\frac{d^2x}{dt^2}$ (as the lase may be)

has same sign

29. Two moles of an ideal monoatomic gas occupies a volume V at 27°C. The gas expands adiabatically to a volume 2 V. Calculate (a) the final temperature of the gas and (b) change in its internal energy.

(1) (a) 189 K (b) – 2.7 kJ

(2) (a) 195 K (b) 2.7 kJ

(3) (a) 189 K (b) 2.7 kJ

(4) (a) 195 K (b) – 2.7 kJ

Sol. [1] $T'V'^{\text{¥}-1}=TV^{\text{¥}-1}$

so $T'=(300K)\left(\frac{1}{2}\right)^{\frac{5}{3}-1}=\frac{300}{(4)^{\frac{1}{3}}}K\approx189\text{K}$

As $W>O$ so $\Delta U<0$

30. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the n[th] power of R. If the period of rotation of the particle is T, then :

(1) $T\propto R^{(n+1)/2}$ **(2)** $T\propto R^{n/2}$

(3) $T\propto R^{3/2}$ for any n **(4)** $T\propto R^{\frac{n}{2}+1}$

Sol. [1] $\frac{K}{{}^{a}n}=m\text{µ}^2R=m\left(\frac{4\text{®}^2}{T^2}\right)R$

$\Rightarrow T\propto R^{\frac{n+1}{2}}$