2024 厦大杯中学物理比赛
2024 XMUM Cup Physics Competition for Secondary School

Question	Acceptable answers		Question	Acceptable answers
1	0.36		16	48
2	2.5		17	1.2
3	31		18	1.6
4	8.2		19	41
5	65		20	-0.14
6	2.8		21	80
7	11		22	8.4
8	0.49		23	1.9
9	4.4		24	50
10	1.5		25	7.4
11	40		26	0.38
12	6.3		27	0.51
13	2.3		28	0.15
14	0.75		29	0.84,0.85 or 0.86
15	65		30	24,25 or 26

Topics	Questions	No. Questions
Mechanics	2,3,4,5,6,7,8,9,11,29,30	11
Thermal Physics	10,12	2
Electromagnetism	19,20,21,22,23	5
Electronics Circuit	15,16,17,18	4
Modern Physics	24,28,26,27,28	5
Waves	13,14	2
Measurement	1	1
	Total	30

Questions 1

A light year is the distance that light travels in vacuum in a year. If the speed of light is $3.00 \times 10^8 m/s$, convert the distance $3.40 \times 10^{12}\ km$ **in unit of light year**. Use 365 days/year, 24 hours/day.

一光年是光在真空中一年内所传播的距离。若光在真空中的速率为$3.00 \times 10^8 m/s$，请将$3.40 \times 10^{12}\ km$的距离转换成光年。使用 365 天/年，24 小时/天。

Ans: 0.36

$$\frac{3.40 \times 10^{15} m}{3.00 \times 10^8 \frac{m}{s}\ 3600 \frac{s}{hour}\ 24 \frac{hour}{day}\ 365 \frac{day}{year}} = 0.36\ year$$

Question 2

A ball is dropped from rest at 30.6 m above ground level. Neglecting the air resistance, find the **time in seconds** the ball takes to reach the ground.

一个小球从距离地面 30.6 m 高处静止释放。忽略空气阻力，求小球落地所需的时间（以秒为单位）。

Ans: 2.5

$$y = \frac{1}{2} g t^2$$

$$30.6 = \frac{1}{2} 9.8 t^2$$

$$t = 2.5\ s$$

Questions 3

If M = 3.6 kg, is hanging by the string in equilibrium as shown in fig. 1. Find the tension in string AB in unit N.

如果 M = 3.6 kg，以细弦悬挂处于如图 1 所示的平衡状态，求弦 AB 中的张力，以牛顿为单位。

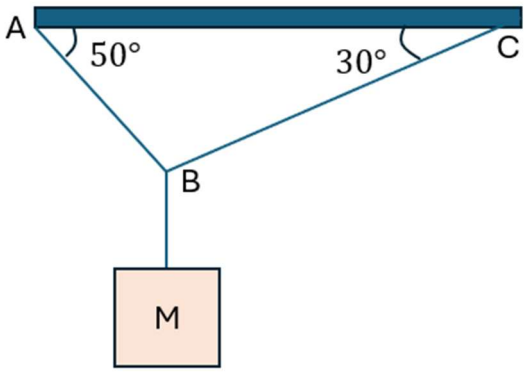
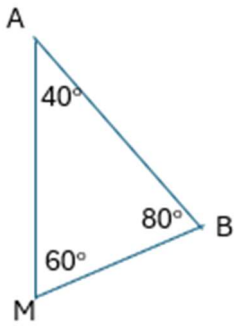


Fig. 1

Ans: 31



The tensions in three of the strings form a triangle ABM as shown in the figure. Using Sine rule,

$$\frac{T_{AB}}{\sin 60°} = \frac{Mg}{\sin 80°}$$

$$T_{AB} = 3.6 \times 9.8 \frac{\sin 60°}{sin\ 80°} = 31\ N$$

Question 4

When a horizontal force F = 24.6 N is applied to block A, the three blocks A, B, and C shown in fig. 2 are in contact and move with the same acceleration. The coefficient of kinetic friction between each block and the ground is 0.2. Find the magnitude of the horizontal force exerted by block B on block C, in newtons.

当水平力 F = 24.6N 作用于物体 A 上时，图 2 所示的三个物体 A、B 和 C，相互接触并以相同的加速度移动。每个物体与地面之间的动摩擦系数为 0.2。求物体 B 对物体 C 施加的水平力的大小，以牛顿为单位。

Ans: 8.2

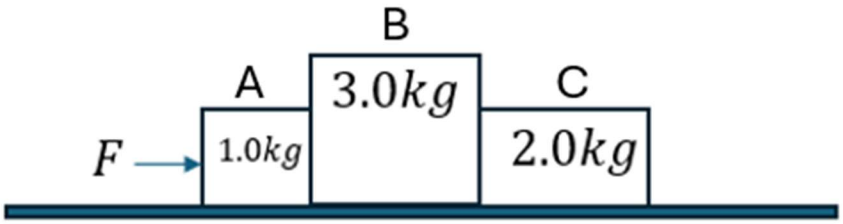


Fig. 2

$$a = \frac{F - \mu g(m_A + m_B + m_C)}{m_A + m_B + m_C}$$

$$F_{BC} - \mu m_c g = m_C a$$

$$F_{BC} = m_C \left(\frac{F - \mu g(m_A + m_B + m_C)}{m_A + m_B + m_C} + \mu g \right)$$

$$= \frac{m_C}{m_A + m_B + m_C} F = 8.2$$

Question 5

Two objects, Red and Green, start their motion at the same instant. Red is sliding down from rest on a smooth slope, Green is thrown from point O. Both get to point P at the same time and at the same speed. The initial height of Red is h from O and distance OP = 1.62h. Determine the initial angle of the throw, θ in degree.

两个物体，红色与绿色，在同一时刻开始运动。红色自光滑的斜坡上静止滑下，绿色从点 O 被抛出.它们同时以相同的速度大小到达点 P。红色物体的初始高度为 h，且距离 OP = 1.62h。求抛出的初始角度 θ（单位：度）。

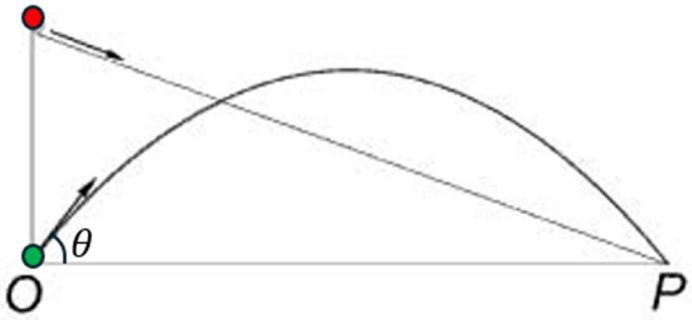


Fig. 3

ns: 65

According to conservation of energy, the speed when red object reaches P

$$\frac{1}{2}mv^2 = mgh \rightarrow v = \sqrt{2gh}$$

The time for the red to reach P is given by $\frac{v-0}{2}t = S \rightarrow t = 2S/v$, where S is the distance on the inclined plane.

For the projectile motion

$$v\cos\theta\, t = OP$$

$$v\cos\theta\frac{2S}{v} = 1.62h$$

$$\cos\theta = \frac{1.62}{2}\frac{h}{S} = 0.81\frac{h}{\sqrt{h^2 + (1.62h)^2}}$$

$$\theta = 64.8°$$

Question 6

Fig. 4 shows the speed v versus height y of a ball tossed directly upward on ground. . In the figure $d = 0.36$ m, the speed at y_A is v_A, and the speed at height y_B is $v_A/3$. Determine the value of v_A in unit m/s.

图 4 中显示了在地面向上抛出的球的速度 v 与高度 y 的关系。距离 d 为 0.36 m。在高度 y_A 处的速度为 v_A。在高度 y_B 处的速度为 $v_A/3$。求 v_A 的值，以 m/s 为单位。

Ans : 2.8

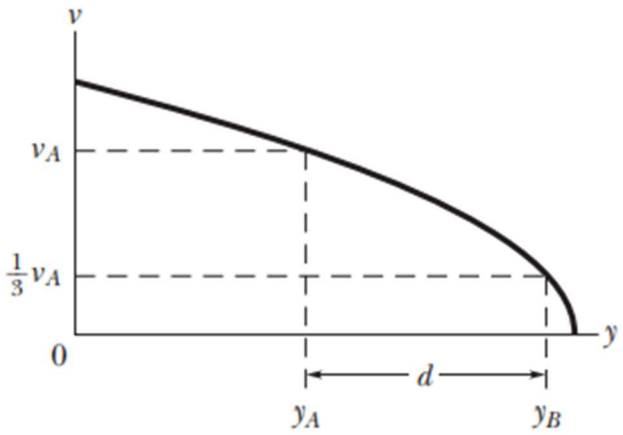


Fig. 4

$$\left(\frac{1}{3}v_A\right)^2 = v_A^2 - 2gd$$

$$\frac{8}{9}v_A^2 = 2gd$$

$$v_A = \sqrt{\frac{9 \times 2 \times 9.8 \times 0.36}{8}} = 2.817\ m/s$$

Question 7

A satellite is travelling above the equator of the Earth. Assuming that its motion is approximately an uniform circular motion with period six hours, determine the altitude of the orbit in unit 10^6 m. The Earth's mass and radius are: 6.0×10^{24} Kg, 6.4×10^3 km.

一颗卫星在地球赤道上空运行。假设它的运动大致为周期为六小时的匀速圆周运动，求轨道离地的高度，以 10^6 m 为单位。

Ans: 11

$$m(R+h)\left(\frac{2\pi}{T}\right)^2 = \frac{GMm}{(R+h)^2}$$

$$R + h = \left(\frac{GM}{4\pi^2}\, T^2\right)^{\frac{1}{3}}$$

$$h = \left(\frac{6.7 \times 10^{-11}\, 6.0 \times 10^{24}}{4\pi^2}\, (6 \times 3600)^2\right)^{\frac{1}{3}} - 6.4 \times 10^6$$

$$= 10.6 \times 10^6 m$$

Question 8

Find the drag force in N (Newtons) on a 0.05 kg body falling through the air at its terminal velocity of 42 m/s near the surface on Earth.

求一个质量为 0.05 kg 的物体在地球表面附近以 42 m/s 的终端速度下坠时所受到的阻力，以牛顿 N 为单位。

Ans: 0.49

$$f = mg = 0.05 \times 9.8 = 0.49\ N$$

Question 9

A bead with mass 0.15 kg slides without friction down a track and then up to the point P at the top of a loop as fig. 5 shows. The bead starts from rest at 6.0 m height from ground. The radius of the loop is 1.5 m. Calculate the magnitude of the normal force on the track in unit N (Newtons) when the bead reaches point P.

一个质量为 0.15 kg 的小球沿无摩擦的轨道滑下，然后滑到环形轨道顶部的点 P。小球从距离地面 6.0 m 的高度静止开始运动。环形轨道的半径为 1.5 m。计算小球到达点 P 时其对轨道所施加的法向力的大小，以牛顿 N 为单位。

Ans: 4.4

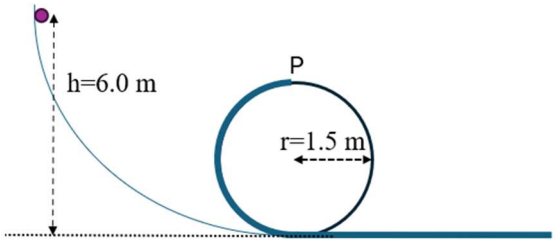


Fig. 5

$$\frac{1}{2}mv^2 = mg(h-2r)$$

The normal force

$$N = \frac{mv^2}{r} - mg$$

$$= 2mg\left(\frac{h}{r} - 2\right) - mg$$

$$= 0.15 \times 9.8\left(2\left(\frac{6}{1.5} - 2\right) - 1\right)$$

$$= 4.4\ N$$

Question 10

An ideal gas undergoes the thermodynamics process abcd as shown in the fig. 6. T_a = 500K, T_d = 200K, p_a=10^5 Pa and p_b = 4x10^5 Pa. In state c, 3V_c = V_a. Find the pressure of the ideal gas in state c in unit $10^5\ Pa$.

某理想气体经过如图 7 所示的热力学过程 abcd。T_a = 500K, T_d = 200K, p_a=10^5 Pa 及 p_b = 4x10^5 Pa. 在状态 c, 3V_c = V_a. 求理想气体在状态 c 的压强，以$10^5\ Pa$为单位。

Ans: 1.5

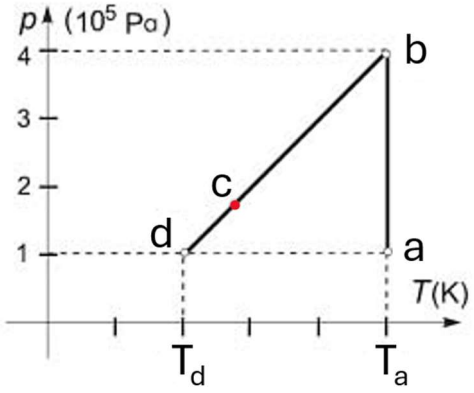


Fig.6

$$\frac{P_a V_a}{T_a} = \frac{P_c V_c}{T_c}$$

$$\frac{P_c}{T_c} = \frac{P_a}{T_a}\frac{V_a}{V_c} = \frac{10^5}{500}\frac{3}{1} = 600$$

$$\frac{P_b - P_c}{T_a - T_c} = \frac{P_b - P_d}{T_a - T_d}$$

$$\frac{400000 - P_c}{500 - P_C/600} = \frac{400000 - 100000}{500 - 200}$$

$$P_c = \frac{500000 - 400000}{\frac{1000}{600} - 1} = 1.5 \times 10^5\ Pa$$

Question 11

There are two identical balls of mass m=2.0kg suspended on two threads of lengths l = 1.0 m and 0.5 m. The threads are made of same material, and in their vertical position the two balls touch each other. If the ball hanging on the longer thread is released from an initial angle exceeding $\theta = 58°$ with respect to the vertical, then the thread breaks just before the collision. What is the maximum initial angle from which this ball can be released, so that non of the threads break after the totally elastic collision?(in unit of degrees.)

有两个质量相同的小球，质量为 m = 2.0 kg，分别悬挂在长度为 1.0 m 和 0.5 m 的两根线上。这两根线由相同的材料制成，在它们垂直时两个小球相互接触。如果悬挂在较长线上的小球从相对于垂直方向超过 $\theta = 58°$ 的初始角度释放，那么在碰撞前线会断裂。求为了在完全弹性碰撞后没有任何一根线断裂，这个小球可以释放的最大初始角度应是多少？（以度为单位）

Ans: 40

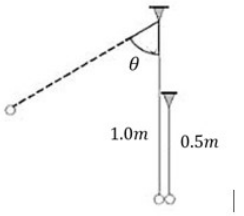


Fig. 7

The speed before collision

$$mgl(1-\cos\theta)=\frac{1}{2}mv^2$$

$$v=\sqrt{2gl(1-\cos\theta)}$$

The centripetal force in string 1

$$F_1=m\frac{v^2}{l}=2mg(1-\cos\theta)$$

After elastic collision, the centripetal force in string 2

$$F_2=m\frac{v^2}{0.5l}=4mg(1-\cos\theta)$$

This force need to smaller than the the critical force

$$F_2\le F_c$$

$$4mg(1-\cos\theta)<2mg(1-\cos\theta_C)$$

$$\cos\theta>\frac{1}{2}+\frac{1}{2}\cos\theta_C=\frac{1}{2}+\frac{1}{2}\cos 58°$$

$$\theta=40°$$

Question 12

A 30 g lead bullet at 0 $°C$ moves at 375 m/s and strikes a block of ice at 0 $°C$. What quantity of ice in gram is melted if all the kinetic energy of the bullet is converted to heat? (Given latent heat of fusion of ice is 334 $J\ g^{-1}$ and the specific heat of lead is 128 $J\ kg^{-1}\ °C^{-1}$.)

一个质量为 30 g 的铅弹在 0°C 下以 375 m/s 的速度运动，并击中一块 0°C 的冰块。如果铅弹的所有动能都转化为热量，有多少克的冰会融化？（已知冰的熔化潜热为 334 $J\ g^{-1}$，铅的比热容为 128 $J\ kg^{-1}\ °C^{-1}$.）。

Ans: 6.3

$$m_i L = \frac{1}{2} m v^2$$

$$m_i = \frac{1}{2}\ (0.03)\ (375)^2 \frac{1}{334000}$$

$$= 6.3\ g$$

Question 13

For a wave travelling along a straight line, the difference between two points in the same phase is 9.2 m, while the distance between two points that are in the opposite phase is 3.45 m. Find the possible value of the maximum wavelength in unit of m.

对于沿直线传播的波，同相位的两个点之间的距离为 9.2 m，而相反相位的两个点之间的距离为 3.45 m。求最大波长的可能值，单位为 m。

Ans: 2.3

Two in phase points $n\lambda = 9.2$

Two opposite phase points $\frac{m\lambda}{2} = 3.45$

$$\frac{n}{m} = \frac{9.2}{6.9} = \frac{4}{3}$$

The maximum possible wavelength is $\lambda = \frac{9.2}{4} = 2.3\ m$

Question 14

A traveling wave is represented by a wave function

$y(x,t) = (0.05\ m)\sin[\frac{2\pi}{3.0m}(x - 0.20\ ms^{-1}t)]$.

When t = 0 s, the first crest of this wave function on the positive side of the x-coordinate origin is located at where? In unit of m.

某前进波的波函数如下

$y(x,t) = (0.05\ m)\sin[\frac{2\pi}{3.0m}(x - 0.20\ ms^{-1}t)]$.

当 t = 0 s 时，该波函数在 x 坐标原点正侧的第一个波峰位于那个位置？以 m 为单位。

Ans: 0.75

When t = 0

$$y(x,0) = (0.05\ m)\sin\left[\frac{2\pi}{3.0m}(x)\right]$$

The first crest happens at $x = \frac{\lambda}{4} = \frac{3.0}{4} = 0.75m$

Question 15

Circuit in fig. 8 below shows a combination of series and parallel resistors connecting to a battery with $\varepsilon mf = 7.8\ V$. Find the current value i in the circuit given. **Give the answer in unit mA.**

图 8 的电路显示一组串联与并联的电阻器连接上电动势为$7.8\ V$的电池。求电路中的电流 i。以 mA 为单位。

Answer: 65

(60 Ω // 20 Ω) + 25 = 40 Ω

(50 Ω + 30 Ω) // 20 = 16 Ω

16 Ω + 24 Ω = 40 Ω

40 Ω // 40 Ω = 20 Ω

20 Ω + 100 Ω = 120 Ω

Ohms law: V = iR

i = V / R

= 7.8 / 120 = 65 mA

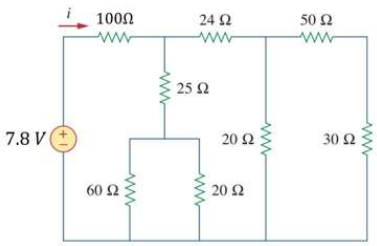


Fig.8

Question 16

A constant current of 2 A flows through a light bulb, and the bulb dissipates 0.96 kJ of energy in the form of light and heat over 10 seconds. Calculate the potential difference across the bulb in unit V.

一灯泡通以 2A 的恒定电流，点炮在 10s 以光和热的形式耗散了 0.96 kJ 的能量。计算经过灯泡的电位差。以 V 为单位。

Answer: 48

The average power dissipated is:

$P = 960/10 = 96\ W$

The voltage drop is:

$v = P/i = 96 / 2 = 48$ V

Question 17

Determine the resistance in Ω of a wire made of a material with a resistivity of 9.42×10^{-8} Ωm is its length is 2.50 m, and its diameter is 0.50 mm.

求一导线的电阻值以 Ω 为单位。导线材料的电阻率为 9.42×10^{-8} Ωm，长度为 2.50 m，直径为 0.50 mm。

Ans: 1.2

$$R = \frac{\rho L}{A} = 9.42 \times 10^{-8} \frac{2.5}{\pi(0.25 \times 10^{-3})^2}$$

$$= 1.2\ \Omega$$

Question 18

A capacitor with a value of 8.0 pF is applied with a voltage of 20 V. Calculate the energy stored in the capacitor when fully charged. **Give the answers in *nJ*.**

某电容值为 8.0 pF 的电容接上 20 V 的电位差。计算电容充满电后储存的能量. 以为 ***nJ*** 单位。

Answer: 1.6

Energy stored, $E = ½ (CV^2) = ½ \times 8.0 \times 10^{-12} \times 20^2 = 1.6\ nJ$

Question 19

A charge Q_A = 20 μC is located at coordinates A (-6, 4, 7), and a charge Q_B = 50 μC is located at coordinates B (5, 8, -2). The distances are given in meters. Assume the permittivity of free space, $\varepsilon_0 = 10^{-9}/(36\pi)$ F/m. find the magnitude of the Coulomb force in mN (milliNewtons) between the charges.

电荷 Q_A = 20 μC 置放在坐标点 A (-6, 4, 7), 电荷 Q_B = 50 μC 置放在坐标点 B (5, 8, -2)。距离是以米为单位。取真空电容率 $\varepsilon_0 = 10^{-9}/(36\pi)$ F/m. 求两电荷间库伦力的大小。以 mN 为单位。

Ans: 41

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 R^2}$$

$R^2 = (5-(-6))^2 + (8-4)^2 + (-2-7)^2 = 218$, hence

$$F = \frac{50 \times 20 \times 10^{-12}}{\frac{10^{-9}}{9} \times 218} = 41.3\ mN$$

Question 20

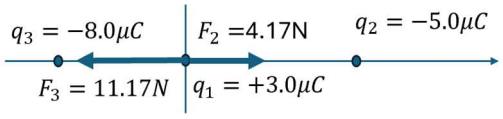
Three point-charges are arranged along the x-axis. Charge q_1 = +3.0 μC is at the origin, and charge q_2 = -5.0 μC is at x = 0.18 m. Charge q_3 = -8.0 μC. Find the position of q_3 in meters such that the net force on q_1 is 7.0 N in the negative x-direction.

Assume the permittivity of free space, $\varepsilon_0 = 10^{-9}/(36\pi)$ F/m.

三个点电荷被置放在 x 轴上。 电荷 q_1 = +3.0 μC 在原点，电荷 q_2 = -5.0 μC 在 x = 0.18 m。电荷 q_3 = -8.0 μC。求电荷 q_3 的位置使得电荷 q_1 的总静电力为 7.0 N 向左。

取真空电容率 $\varepsilon_0 = 10^{-9}/(36\pi)$ F/m.

Ans: -0.14



$$F_2 = \frac{3 \times 5}{\frac{10^{-9}}{9} \times 0.18^2} = 4.17N$$

Net Force = F_2+F_3 = -7N, F3 = -7-4.17 = -11.17N. Hence

$$r = \sqrt{\frac{4\pi\varepsilon_0 Q_1 Q_2}{F_3}} = \sqrt{\frac{3 \times 8}{\frac{10^{-9}}{9} \times 11.17}} = \pm 0.14m$$

Question 21

A particle with a charge of q = -6.00 ×10^{-9} C is placed at point A in a uniform electric field. The particle starts from rest and moves to point B, which is 5 meters away, gaining a kinetic energy of 3.00 × 10^{-7} J. If the electric potential at point A is +30.0 V, find the electric potential at point B **in volts.**

某粒子带电量 q = -6.00 ×10^{-9} C，被置放在匀强电场中的 A 点。粒子由静止开始移动至 5m 外的 B 点后，获得了动能 3.00 × 10^{-7} J。若点 A 的电位为+30.0 V， 求点 B 的电位。以 V 为单位。

Ans: 80

Potential Energy = q(V_A-V_B) = Kinetic Energy, KE

$V_B = V_A – KE/q = 30 – 3 \times 10^{-7}/(-6\times10^{-9}) = 80$ V

Question 22

A deuteron (the nucleus of an isotope of hydrogen) has a mass of 3.3 × 10^{-27} kg and a charge of q = 1.6 × 10^{-19} C. The deuteron travels in a circular path with a radius of 6.93 mm in an uniform magnetic field with magnitude 2.50 T. Find the speed of the deuteron in units 10^5 m/s.

一个氘核（氢同位素的原子核）质量为 3.3 × 10^{-27} kg，电荷量为 q = 1.6 × 10^{-19} C。在磁感应强度为 2.50 T 的均匀磁场中，氘核沿半径为 6.93 mm 的圆形轨道运动。求氘核的速度，以 10^5 m/s 为单位。

Ans: 8.4

$$|q|vB = \frac{mv^2}{R}$$

$$v = \frac{qBR}{m} = \frac{1.6 \times 10^{-19} \times 2.5 \times 6.93 \times 10^{-3}}{3.3 \times 10^{-27}} = 8.4 \times 10^5 m/s$$

Question 23

A particle of mass 0.195 g carries a charge of -2.50 × 10^{-8} C. The particle is given an initial horizontal velocity that is due north and has magnitude 4.00 × 10^4 m/s. Determine the magnitude

of the minimum magnetic field in Tesla that will keep the particle moving in the earth's gravitational field in the same horizontal, northward direction. All resistant forces are negligible.

一个质量为 0.195 g 的粒子带有电荷 -2.50 × 10^{-8} C。该粒子被赋予初始水平速度，方向为正北，速度大小为 4.00 × 10^{4} m/s。求使该粒子在地球引力场中保持沿相同水平正北方向运动所需的最小磁场强度，单位为 T。忽略所有阻力。

Ans: 1.9

$$mg = |q|vB$$

$$B = \frac{mq}{qv} = \frac{0.195 \times 10^{-3} \times 9.8}{2.5 \times 10^{-8} \times 4 \times 10^{4}} = 1.91T$$

Question 24

The yellow light of wavelength $\lambda = 589\,nm$ is registered by the human eye when the minimal power of radiation at the retina is equal to $P = 1.68 \times 10^{-8}\,W$. In this case, how many photons hit the retina in one second? **Give the answer in billions (10^9).**

当波长为 $\lambda = 589\,nm$的黄色光被人眼接收到时，视网膜上能够侦测的最小辐射功率为 $P = 1.68 \times 10^{-8}\,W$。在这种情况下，每秒钟有多少个光子击中视网膜？请以十亿（10^9）为单位给出答案。

Ans: 50

Solution:

In one second, the eye absorbs energy $E = 1.7 \times 10^{-8}\,J$.

Each single photon has energy $E1 = \frac{h\,c}{\lambda} = \frac{6.6 \times 10^{-34} J\,s\; 3 \times 10^{8} m/s}{589 \times 10^{-9} m} = 0.0336 \times 10^{-17}\,J$.

So, there are $\frac{E}{E1} = \frac{1.68 \times 10^{-8}}{0.0336 \times 10^{-17}} = 50 \times 10^{9}$ photons (rounded to fifty billion).

Question 25

Radiation of wavelength $\lambda = 0.005\,nm$ is scattered from free electrons. What is the wavelength of the rays scattered at the angle of $\frac{\pi}{2}$? **Give the answer in unit of** pm (picometers)**.**

波长为$\lambda = 0.005\ nm$的辐射被自由电子散射，求散射角为$\frac{\pi}{2}$时辐射的波长，答案以 pm 为单位。

Ans: 7.4

Solution:

This is the case of Compton scattering. The Compton formula is $\lambda' = \lambda + \frac{h}{m\,c}(1 - cos\theta)$.

In the present case $(\theta = pi/2)$ and therefore the original wavelength is increased by the Compton wavelength

$$\lambda_C = \frac{h}{m\,c} = 2.42 \times 10^{-12} m = 0.00242\ nm$$

.

The new wavelength is $\lambda' = 0.005 + 0.00242 = 7.42\ pm$.

Question 26

Given the ionization energy of a hydrogen atom 13.6 eV, how much energy is required to remove the electron in n=6 orbital outside the hydrogen atom? **Give the answer in unit eV.**

已知氢原子的游离能为 13.6 eV, 移除氢原子外处在 n=6 的轨道上的电子需要多少的能量? 以 eV 为单位。

Ans: 0.38

Solution:

According to the Bohr model, the electron energies in hydrogen are quantized as follows

$$E_n = -13.6\ \frac{1}{n^2}\ eV$$

In this notation the electron becomes unbound at energy zero. Therefore, the energy to remove it from n=6 state is

$$-E_6 = 13.6\ \frac{1}{6^2} = 0.38\ eV$$

.

Question 27

In an experiment of photoelectric effect, Sodium surface is bombarded by photons. Given that work function of Sodium 2.42 eV, find the cutoff wavelength **in unit μm** (micrometers).

在一光电效应实验中，金属钠的表面被光子撞击。已知钠的功函数为 2.42 eV，求截止波长。以μm为单位。

Ans: 0.51

Solution:

$$E = hf - \phi$$

$$0 = \frac{hc}{\lambda} - \phi$$

$$\lambda = \frac{hc}{\phi} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{2.42 \times 1.6 \times 10^{-19}} = 5 \times 10^{-7}\ m = 0.51\ \mu m$$

Question 28

Determine the de Broglie wavelength of thermal neutrons at room temperature $T = 280\ K$. Their kinetic energy is $\frac{3}{2}kT$, where $k = 1.38 \times 10^{-23} J/K$ and the mass of a neutron is $m = 1.65\ \times 10^{-27} kg$. **Give the answer in unit *n*m** (nanometers).

求热中子在温度 280K 的德布罗意波长。热中子的平均动能为$\frac{3}{2}kT$，其中$k = 1.38 \times 10^{-23} J/K$，中子质量为$m = 1.65\ \times 10^{-27} kg$. 答案以为 *n*m 单位。

Ans: 0.15

Solution:

The kinetic energy is $\frac{3}{2}kT = \frac{p^2}{2m} = \frac{h^2}{2m\,\lambda^2}$

From here the de Broglie wavelength is

$$\lambda = \frac{h}{\sqrt{3\ m\ k\ T}} = \frac{6.6\ \times 10^{-34}}{\sqrt{3\ 1.65\ \times 10^{-27} 1.38 \times 10^{-23}\ 280}}$$

$$= \frac{6.6\ \times 10^{-34}}{43.73\ \times 10^{-25}} = 0.15 \times 10^{-9} = 0.15\ n\text{m}$$

Question 29

Solution:

The velocities of the wall before and after collision are considered zero. So,

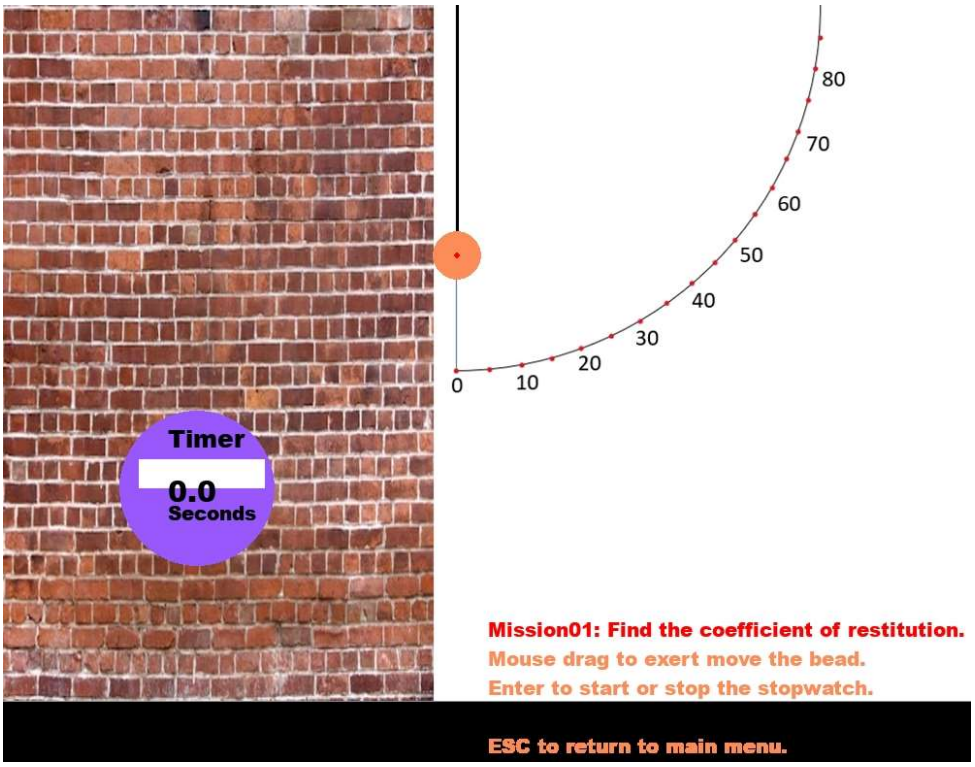
$$\varepsilon \equiv \frac{|v_1|}{|u_1|}$$

$$= \frac{\sqrt{(1-\cos\theta_v)}}{\sqrt{(1-\cos\theta_u)}}$$

θ_u and θ_v are the maximum angles before and after collision.

θ_u	θ_v	ε
60	**51**	**0.861**
50	**42**	**0.848**
40	**34**	**0.855**
30	**26**	**0.853**
20	**17**	**0.851**

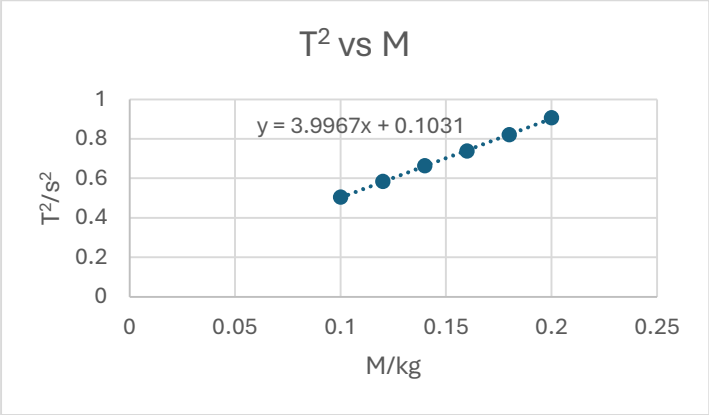
Ans: 0.84,0.85 or 0.86



Question 30

Solution:

M	10T	T^2
0.10	7.1	0.5041
0.12	7.64	0.5837
0.14	8.14	0.6626
0.16	8.59	0.7379
0.18	9.06	0.8208
0.20	9.52	0.9063



$$T^2 = \frac{4\pi^2}{k}(M + m_{eff})$$

The slope is $\frac{4\pi^2}{k} = 3.9967$,

The y-intercept is $\frac{4\pi^2}{k} m_{eff} = 0.1031$, so we get $m_{eff} = 0.0258\, kg = 26\, g$

Ans: 24,25,26