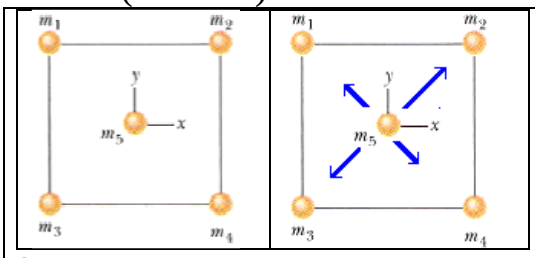
Ayman Ghannam
Chapter 13
Gravitation

Q.1 Two point particles of 200 kg and 500 kg are separated by a distance of 0.400 m. At what distance from the 500 kg particle can a point particle of 50.0 kg mass be placed between the two particles such that the 50.0 kg particle experiences a net zero gravitational force? (0.245 m)



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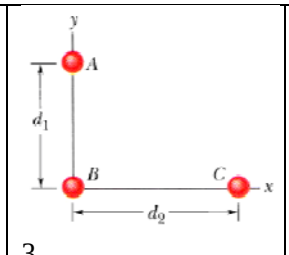

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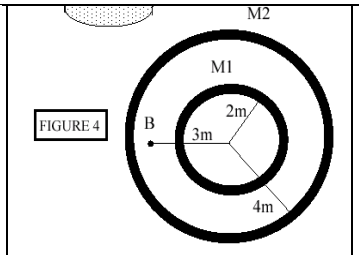

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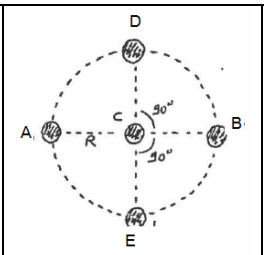

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Q.2 In Fig. a square of edge length 20.0 cm is formed by four spheres of masses m_1 = 5.00 g, m_2 = 3.00 g, m_3 = 1.00 g, and m_4 = 5.00 g. In unit-vector notation, what is the net gravitational force from them on a central sphere with mass m_5 = 2.50 g?
Fnet=1.67E-14N $\vec{F}_{net} = F_{net}(\cos 45°\hat{i} + \sin 45°\hat{j}) = (1.18\times10^{-14}\,\text{N})\,\hat{i} + (1.18\times10^{-14}\,\text{N})\,\hat{j}$

Q.3 In Fig., three 5.00 kg spheres are located at distances d_1 = 0.300 m and d_2 = 0.400 m. What are the (a) magnitude and (b) direction (relative to the positive direction of the *x* axis) of the net gravitational force on sphere *B* due to spheres *A* and *C*?
$\vec{F}_{net} = \left(1.04\times10^{-8}, 1.85\times10^{-8}\right) \Rightarrow \left(2.13\times10^{-8} \angle 60.6°\right)$.

Q.4 Planet X has the same mass as earth ($M_X = M_E$) but has ½ the radius ($R_X = 0.5\ R_E$). What is g_x , the acceleration of gravity on planet X?4g

Q.5 Two concentric shells of uniform density having masses M1 and M2 and Radii R_1 =2.0 m, R_2 = 4.0 m are situated as shown in FIGURE. Find the gravitational FORCE on a particle of mass m placed at point B at a distance of 3.0 m from the center :A1 (G*M1*m)/9.

Q.6 How much work is done by the Moon's gravitational field in moving a 995 kg rock from infinity to the Moon's surface? [The Moon's radius and mass are 1.74×10^{6} m and 7.36×10^{22} kg, respectively.](2.8E9J)

Q.7 A 1000 kg satellite is in a circular orbit of radius = $2R_e$ about the Earth. How much energy is required to transfer the satellite to an orbit of radius = $4R_e$? (R_e = radius of Earth = 6.37×10^6 m, mass of the Earth = 5.98×10^{24} kg). (7.8E9J)

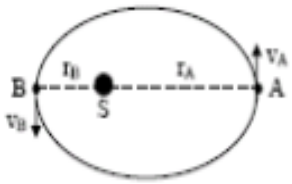
Q.8 Four stars (A, B, D, E), of equal mass, rotate in the same direction around a fifth star C of the same mass located at their common center of mass (see figure). The radius of the common orbit is R. What minimum speed would star A need **in order to depart from its companions for good?** (Express your answer in terms of G, M, R). **{(3+2√2)GM/R}**

Q.9 A satellite of mass 1300 kg is rotating around the earth in an orbit of radius 0.665×10^{7} m. Then the satellite moves to a new orbit of radius 4.230×10^{7} m. What is the change in its mechanical energy? (3.29E10J)

Q.10 An object is fired vertically upward from the surface of the Earth (Radius = R_e) with an initial speed of (Vesc)/2, where (Vesc = escape speed). Neglecting air resistance, how far above the surface of Earth will it reach? (1/3 RE)

Q.11 The planet Mars has a satellite, Phobos, which travels in a circular orbit of radius 9.40×10^6 m, with a period of 2.754×10^4 s. Calculate the mass of Mars from this information. (6.5E23kg)

Q.12 The Fig shows a planet traveling in a counterclockwise direction on an elliptical path around a star S located at one focus of the ellipse. The speed of the planet at a point A is v_A and at B is v_B. The distance $A_S = r_A$ while the distance $B_S = r_B$. The ratio v_A/v_B is (rB/rA)



Q.13 At what distance above the surface of Earth (radius = R_e) is the magnitude of the gravitational acceleration equal to g/16? (Where g = gravitational acceleration at the surface of Earth). (3RE)

Q.14 The magnitude of the acceleration due to gravity at the North Pole of planet Neptune is 10.7 m/s^2. Neptune has a radius of 2.5 x 10^4 km and rotates once around its axis in 16.0 hours. What is the magnitude of the acceleration due to gravity at the equator of Neptune? A: 10.4 m/s^2

Q.15 If the gravitational acceleration at the surface of Earth is 9.8 m/s^2, at what distance from the Earth's center (inside the Earth) will the gravitational acceleration be 4.0 m/s^2? (2600km)

Q.16 A spherical asteroid has a radius of 500 km. The acceleration due to gravity at the surface of the asteroid is 3.00 m/s^2. With what speed will an object hit the surface of the asteroid if it is dropped from rest from 300 km above the surface? (v = 1.06 km/s)

Q.17 A planet makes a circular orbit with period T around a star. If the planet were to orbit, at the same distance, around a star with three times the mass of the original star, what would be the new period? $T_n = 0.577\,T$

Q.18 A satellite of Jupiter, has an orbital period of 1.77 days and an orbital radius of 4.22×10^5 km. Determine the mass of Jupiter. (1.90×10^{27} kg)

Summary of equations:

$$F = G\frac{m_1 m_2}{r^2}, \quad g = a_g - \omega^2 R_E, \quad U(r) = -\frac{GMm}{r}, \quad v_{esc} = \sqrt{\frac{2GM}{R}}$$

$$\frac{dA}{dt} = \frac{L}{2m} = \text{constant}, \quad L = mr^2\omega$$

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM} = \text{constant}$$

$$v = \sqrt{\frac{GM}{r}} \quad E = -\frac{1}{2}\frac{GmM}{r}$$