

Planet Mars is located at a mean distance of 146,510,000 km from Earth (i.e.  $23000R_E$ ). The mass of Earth is approximately 8 times the mass of Mars.

- 1) The potential energy of Mars due to Earth is:

a)  $-4.67 \times 10^{27}$  J  
 b)  $-2.03 \times 10^{27}$  J  
 c)  $-6.25 \times 10^{27}$  J  
 d)  $-4.39 \times 10^{27}$  J  
 e)  $-0.29 \times 10^{27}$  J

$$U = -\frac{GM_E(M_E/8)}{23000R_E}$$

$$= -\frac{gR_E M_E}{(8)(23,000)} = -2.03 \times 10^{27} \text{ J}$$

- 2) If suddenly Mars stopped its motion with respect to Earth and started falling towards us, what would Mars' kinetic energy be upon impact?

a)  $4.67 \times 10^{31}$  J  
 b)  $2.03 \times 10^{31}$  J  
 c)  $6.25 \times 10^{31}$  J  
 d)  $4.39 \times 10^{31}$  J  
 e)  $0.29 \times 10^{31}$  J

$$K_{\text{IMPACT}} + U_{\text{IMPACT}} = U_{\text{INITIAL}}$$

$$K_{\text{IMPACT}} = \frac{GM_E M_E/8}{R_E} - \frac{GM_E M_E/8}{23,000 R_E}$$

$$= 4.67 \times 10^{31} \text{ J}$$

- 3) What would Mars' speed be upon impact?

a) 11.2 km/s  
 b) 53.6 km/s  
 c) 91.5 km/s  
 d) 22.0 km/s  
 e) 34.7 km/s

$$\frac{1}{2}(M_E/8)v^2 = 4.67 \times 10^{31}$$

$$v = 11.2 \text{ km/s}$$

A given neutron star has a radius of 6.37 km (i.e.  $R_E/1000$ ) and 1000 times Earth's mass.

- 4) The surface gravity of this neutron star is:

a)  $9.81 \times 10^8$  m/s<sup>2</sup>  
 b)  $9.81 \times 10^5$  m/s<sup>2</sup>  
 c)  $9.81 \times 10^3$  m/s<sup>2</sup>  
 d)  $9.81 \times 10^9$  m/s<sup>2</sup>  
 e)  $9.81 \times 10^6$  m/s<sup>2</sup>

$$g = \frac{GM}{R^2} = \frac{G 1000 M_E}{(R_E/1000)^2}$$

$$= 10^9 \frac{GM_E}{R_E^2} = 9.81 \times 10^9 \text{ m/s}^2$$