2nd section A test for Clockwork Universe: Time 30 minutes

1. Choose the correct value from the list below for the energy stored in a 100 μF capacitor with a p.d. of 25 V across it.

0.0025 J   0.031 J   0.063 J   2.5 J

energy = ……………….J

[1]

2. The graph in Fig. 1 shows the decay curve for a sample of radioactive nuclei decaying to form stable nuclei.

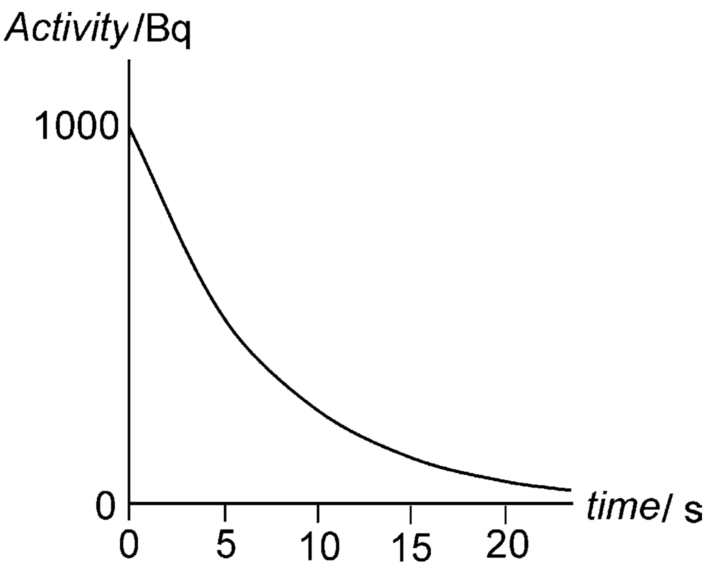

Fig. 1

(a) Show that the decay constant λ is about 0.14 s^{-1}.

[2]

(b) Show that the sample originally contained about 7000 radioactive nuclei.

[2]

3. The graph in Fig. 3 shows the displacement-time graph for a 0.50 kg mass attached to a spring.

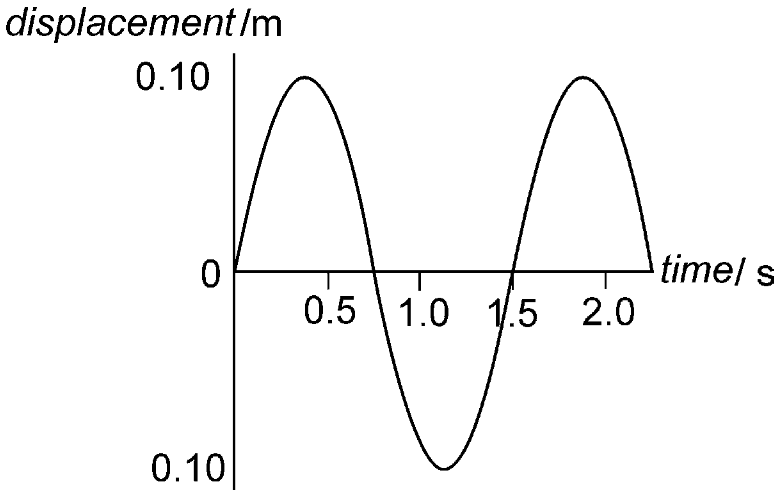

Fig. 3

(a) State the period of oscillation of the mass-spring system.

period = ………………….. s [1]

(b) Calculate the spring constant k of the spring.

k = ……………………… unit …..…… [3]

(c) Without calculating any values, sketch on Fig. 3 above the acceleration-time graph for this oscillation.

[2]

4. A 2200 W kettle contains 2.5 kg of water. Calculate the rate at which the temperature rises.

$c = 4200 \text{ J kg}^{-1} \text{ K}^{-1}$

[2]

5. Fig. 4 shows gravitational equipotentials near a binary star system consisting of two stars A and B.

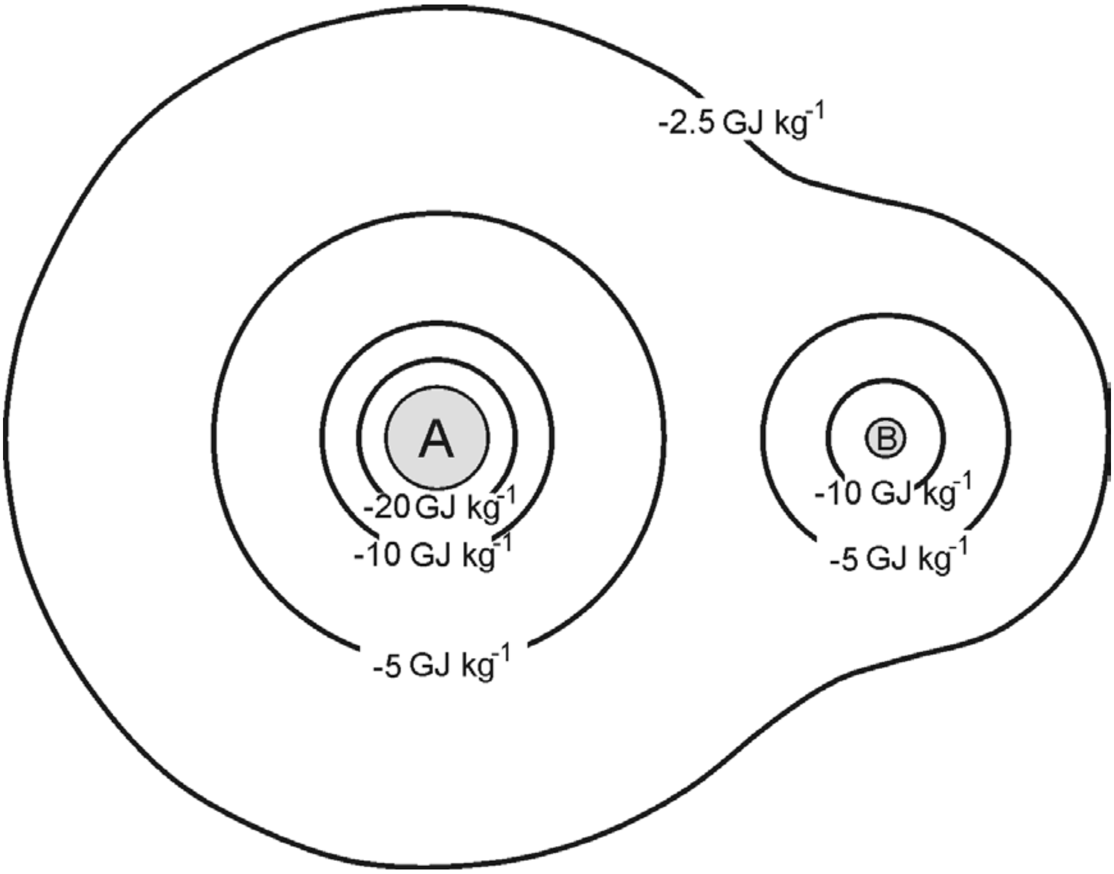

Fig. 4

(a) Explain how the gravitational equipotentials show that the gravitational field strength becomes weaker as you move away from each star.

[2]

(b) Estimate the energy needed to move a 100 kg mass from the surface of star A to a very great distance away.

[3]

(c) Mark with an X the point on the diagram where the resultant gravitational field strength is 0.

[1]

6. Calculate the centripetal acceleration of the Earth as it orbits the Sun.

radius of Earth's orbit = 1.5×10^{11} m

1 year = 3.2×10^{7} s

[3]

7. 0.50 mol of an ideal gas at 350 K occupy a volume of 0.40 m^3.

(a) Show that the pressure is about 3600 Pa.

$R = 8.3$ J $K^{-1}mol^{-1}$

[2]

(b) Calculate the new pressure if the temperature drops to 290 K, the volume remaining constant.

[2]

8. In a hydrogen atom, the lowest possible energy state is 1.6×10^{-18} J below the next higher energy state.

(a) Show that the Boltzmann factor for these two energy states at a temperature of 6000 K is about 5×10^{-9}.

$k = 1.4 \times 10^{-23}$ J K^{-1}

[2]

(b) Explain why, at a temperature of 6000 K, only about 1 hydrogen atom in 2×10^8 will be in the higher of these two states.

[2]