2024 Ph H2 Q4

Section: Our Dynamic Universe

Topic: Gravitation, Energy, Momentum

Question Summary

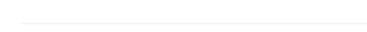
This question relates to the DART mission's collision with the asteroid Dimorphos. It involves:

- Comparing the mass of Earth and Didymos (orders of magnitude),
- Calculating gravitational force between Earth and Didymos,
- Calculating kinetic energy transferred from DART to Dimorphos,
- Sketching the force-time graph during the impact.

Worked Solution

(a) (i) Comparing masses in orders of magnitude: • Mass of Earth = $6.0 \times 10^{24}~\mathrm{kg}$

- Mass of Didymos = $5.3 \times 10^{11}~\mathrm{kg}$
- Difference in order of magnitude = 24 11 = 13



🔽 Answer: 13 orders of magnitude

Use Newton's Law of Universal Gravitation:

(a) (ii) Gravitational force between Earth and Didymos:

$$F = G \frac{m_1 m_2}{r^2}$$

 $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{kg}^{-2}$

Where:

- $m_1 = 6.0 \times 10^{24} \; \mathrm{kg}$ (Earth)
- . $m_2 = 5.3 imes 10^{11} \mathrm{\ kg}$ (Didymos)
- $r = 1.1 \times 10^{10} \text{ m}$

$$F = \frac{(6.67 \times 10^{-11})(6.0 \times 10^{24})(5.3 \times 10^{11})}{(1.1 \times 10^{10})^2}$$

 \checkmark Answer: $1.76 \times 10^6 \text{ N}$

 $F = \frac{2.124 \times 10^{26}}{1.21 \times 10^{20}} = 1.76 \times 10^6 \text{ N}$

$E_k = \frac{1}{2}mv^2$

(b) (i) Kinetic energy of DART before impact:

•
$$m = 570 \text{ kg}$$

• v = 6.6 km/s = 6600 m/s

Answer: $1.24 \times 10^{10} \text{ J}$

 $E_k = \frac{1}{2} \times 570 \times 6600^2 = 1.24 \times 10^{10} \text{ J}$

Sketch a curve starting at zero, rising smoothly to a peak

(b) (ii) Force-time graph for collision:

(representing maximum force), then symmetrically falling back to zero. This represents the short-duration impact.



📏 (Graph is qualitative and does not require values on axes)

Revision Tips

graphs.

- Mean to compare values in orders of magnitude.
- Use Newton's Law of Universal Gravitation confidently with standard form.
- the speed, quadruple the energy! Impact forces often form a symmetric pulse in force-time

Kinetic energy depends quadratically on speed — double