Artemis II Gravity Assist Problem

Answer Key

Physics 11

(a) Force of Gravity

Distance:

$$r = 50{,}000 \text{ km} = 5.0 \times 10^7 \text{ m}$$

$$F = \frac{GMm}{r^2} = \frac{(6.67 \times 10^{-11})(1.8 \times 10^4)(7.35 \times 10^{22})}{(5.0 \times 10^7)^2}$$

$$F \approx 3.53 \times 10^1 \text{ N}$$

Answer: $F \approx 35.3$ N (toward the Moon)
FBD: Single force pointing toward the Moon.
Explanation: In space, gravity is the only significant force acting, so it is the net force.

(b) Acceleration

$$a = \frac{F}{m} = \frac{35.3}{1.8 \times 10^4}$$

$$a \approx 1.96 \times 10^{-3} \text{ m/s}^2$$

Comparison: This is much smaller than 9.8 m/s^2.

(c) Closest Approach

$$r = (2.00 \times 10^6 + 1.74 \times 10^6) = 3.74 \times 10^6 \text{ m}$$

$$F = \frac{(6.67 \times 10^{-11})(1.8 \times 10^4)(7.35 \times 10^{22})}{(3.74 \times 10^6)^2}$$

$$F \approx 6.31 \times 10^3 \text{ N}$$

Answer: $F \approx 6.31 \times 10^3$ N
Explanation: As distance decreases, force increases significantly due to the inverse-square relationship.

(d) Direction Change

Answer:

- Gravity continuously pulls the spacecraft toward the Moon.
- This changes the direction of velocity without needing a force in the direction of motion.
- The result is a curved (accelerated) path.

(e) Challenge

$$\frac{GMm}{r^2} = \frac{mv^2}{r}$$

Cancel m:

$$\frac{GM}{r} = v^2$$

$$v = \sqrt{\frac{GM}{r}}$$

$$v = \sqrt{\frac{(6.67 \times 10^{-11})(7.35 \times 10^{22})}{3.74 \times 10^6}}$$

$$v \approx 1.14 \times 10^3 \text{ m/s}$$

Answer: $v \approx 1.14 \times 10^3$ m/s

Explanation: Higher velocity at closest approach leads to a more effective slingshot maneuver.