

- 2 (a) State Newton's second law of motion.

.....  
.....  
..... [1]

- (b) Solar sail is a method of spacecraft propulsion using radiation pressure exerted by sunlight on large mirrors. The first spacecraft to make use of the technology was IKAROS, launched in 2010.

The solar sail in Fig. 2.1 uses the momentum of photons in solar radiation for propulsion.

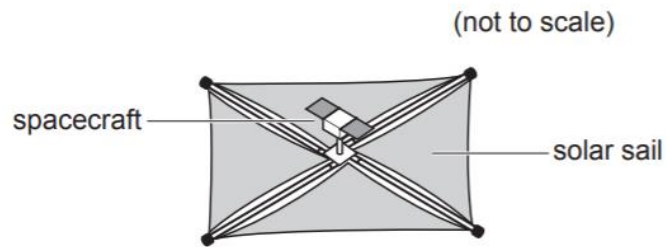


Fig. 2.1

- (i) Show that the change in momentum of the spacecraft when a photon that is incident along the normal on a solar sail is reflected is given by  $\frac{2E}{c}$ , where  $E$  is the energy of the photon and  $c$  is the speed of light in vacuum.

[3]

- (ii) The total power of the radiation received from the Sun on a  $1.0 \text{ m}^2$  area of solar sail is  $1400 \text{ W}$  when the spacecraft is near the Earth. Using your answers from (b)(i), calculate the thrust force from photons reflection.

- thrust force = ..... N [3]
- (iii) The spacecraft has a mass of 1000 kg and a solar sail of area  $1.0 \times 10^6 \text{ m}^2$ .  
Calculate the acceleration of the spacecraft.

acceleration = .....  $\text{m s}^{-2}$  [1]

- (iv) State and explain the difference, if any, your answer in **(b)(iii)** if the solar sail is non-reflective, so that photons are absorbed instead of reflected.

.....  
..... [2]

[Total: 10]

