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Answers

Practice-for-exam questions

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The general theory of relativity

- 1 The equivalence principle states that being in an accelerating aircraft is indistinguishable from being in a gravitational field. The clock at the top of the mountain is further from the centre of the Earth and in a weaker field, and therefore runs faster than the clock at the bottom of the mountain.
- 2 If the clocks were not calibrated to run more slowly on Earth, a clock in space it would run faster than the Earth clock. This would lead to the receiver miscalculating the position of each satellite and therefore concluding the wrong position. Each day the time difference between the two clocks would increase by 38 microseconds and therefore the positioning error would increase.

The photoelectric effect revisited

- 1 Radio waves have a much lower frequency than visible light and therefore the photon energy is much less, and is too low to provide the energy for an electron to be released from a metal.
- 2 A gold leaf electroscope has a thin gold leaf that is repelled from the stem when the electroscope is charged (see Figure 1 on page 14 of the magazine). When the electroscope is discharged the leaf falls.

Clean the surface of the zinc block to remove any dirt and any metal oxide that might have built up.

Place the clean block on the plate of the electroscope.

Give the electroscope a negative charge by rubbing a polythene rod with a cloth and touching the rod onto the zinc block of the electroscope: the leaf rises.

Shine UV light on the block. The UV light transfers energy electrons in the zinc so they can escape. The electroscope loses its negative charge and the leaf falls.

Visible light (which has lower energy photons) does not cause the charge to leak away, even if the intensity of the light is increased.

If you give the electroscope a positive charge, e.g. by using a rubbed acetate rod, it is not discharged when a UV light is shone, because the positive charge prevents the photoelectrons from leaving.

At a glance: water power

- 1 Use Equation 4.3 to calculate the maximum and minimum output powers from one of the Three Gorges turbines.

Assume that efficiency $\eta = 90\% = 0.90$

and use density of water $\rho = 1000 \text{ kg m}^{-3}$

For minimum output power:

$$\text{flow rate } Q = 600 \text{ m}^3 \text{ s}^{-1}$$

$$\text{water head } h = 80 \text{ m}$$

$$P = \eta \rho Qgh$$

$$= 0.90 \times 1000 \text{ kg m}^{-3} \times 600 \text{ m}^3 \text{ s}^{-1} \times 9.8 \text{ m s}^{-2} \times 80 \text{ m}$$

$$= 423 \text{ MW}$$

For maximum output power:

$$\text{flow rate } Q = 950 \text{ m}^3 \text{ s}^{-1}$$

$$\text{water head } h = 113 \text{ m}$$

$$P = 0.90 \times 1000 \text{ kg m}^{-3} \times 950 \text{ m}^3 \text{ s}^{-1} \times 9.8 \text{ m s}^{-2} \times 113 \text{ m}$$

$$= 946 \text{ MW}$$

So the stated 700 MW is in the range suggested by the minimum and maximum values given for flow rate and height.

2 If the 32 700 MW turbines each operated for 365 days per year the output would be :

$$P = 32 \times 700 \text{ MW} \times (365 \times 24) \text{ h}$$

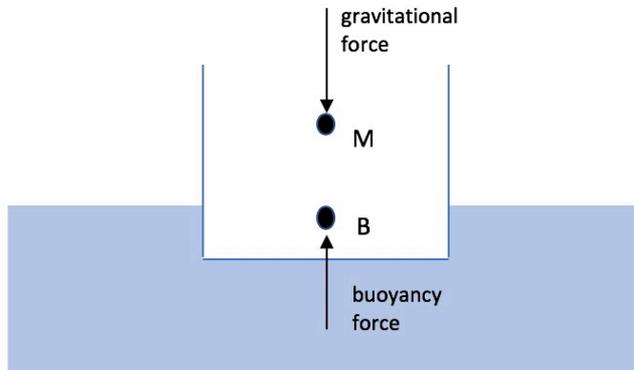
$$= 196 \times 10^6 \text{ MWh}$$

$$= 196 \text{ TWh}$$

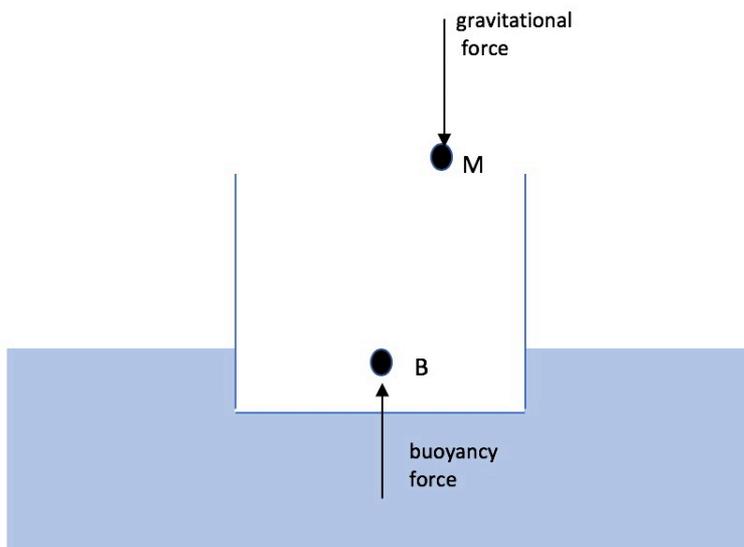
This is approximately one twentieth of the world production. The calculation assumes all the turbines working full time, so in reality the fraction would be smaller.

On the water

1



Initially the buoyancy force and the gravitational force are equal and opposite and along the same line of action.



When you stand up and move to the side, the centre of mass moves sideways and is no longer above the centre of the boat.

The forces are no longer in line and there will be a couple, which will cause rotation of the boat. Rotation will increase the distance between the two forces and therefore increases the couple. This increases the rotation rate. So the rotation accelerates until the boat has capsized. This is an example of positive feedback.

Our radioactive environment

1 Radioisotopes behave the same way chemically as their non-radioactive equivalents because all isotopes of an element have the same number of protons and electrons.

Strontium-90 will be processed by the body in a similar way to calcium and will accumulate in bones and teeth, where it will continue to emit radiation, unlike isotopes that are digested and pass out of the body.

2 Long-haul aircraft fly at higher altitudes and for more hours than short-haul flights, so the crew will be exposed to higher levels of cosmic radiation for longer times, thus exposing them to higher levels of radiation than those who work on short-haul flights.

Records show when there is a risk that air crew have been exposed to the maximum allowed dose of radiation in a particular year, and they can be moved to other duties.

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