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How much power would be required to push someone backwards using light?

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Abstract
This paper calculates the power required to knock the average woman backwards by 1 m in 1 second using light. The power was calculated to be 4.62×10^{33} Watts assuming there is negligible friction between the woman and the ground. The force to do so was initially calculated and then the intensity and required power was then determined. The amount of power required is 12×10^{6} times greater than that provided by the Sun and so the temperature increase would be unbearable and unrealistic.

Introduction
When light is focused on an object, such as under a microscope, there is a force applied to it. If the intensity of the light is too great, the force being exerted on the object could cause deformation. In terms of larger objects, such as those seen by the human eye, usually the force exerted by natural light is unnoticeable and insignificant. However, even if unnatural, it is possible to determine the power and intensity of a light source to knock a woman backwards.

To do so, assumptions must be made. The woman, being the object in this scenario, will be of average height and width. There will be negligible friction between her and the ground, therefore no opposing forcing acting horizontally. If opposing forces were considered, the intensity of light would be greater to overcome these. It is also assumed the light source will be applying a force which acts horizontally on the woman, as if from a setting sun. For this scenario, the distance moved will be 1 m and this will be within 1 second.

Theory and application
It is commonly known that force (F) is equal to the mass of the object (m) multiplied by the acceleration (a), shown in equation 1.

$$F = ma \tag{1}$$

The acceleration of the woman must be determined, as this is equivalent to the change in speed over the change in time. This is only being considered in a single dimension and so the acceleration can be found using equation 2 [1].

$$v^2 = u^2 + 2as \tag{2}$$

In equation 2, v is equal to the final speed (1 ms^{-1}), u the initial speed (0 ms^{-1}), a the acceleration and s the distance travelled (1 m). This can be rearranged, giving an acceleration of 0.5 ms^{-1}.

The mass of the woman must then be calculated. In the UK, the average woman weights 70.2 kg [2]. Therefore, by using equation 1, the force needed would be 35.1 N.

Equation 3 will be used and rearranged to work out the intensity, I, of the light source.

$$F = \frac{IA}{c} \tag{3}$$

The area, A, refers to the area of the object, in this case this will be the approximate rectangular area of the woman and c being the speed of light. This method ignores the head and any limbs or clothing which sticks out from the main area. The average UK woman has a height of 1.616 m and width of 0.395 m [2,3]. This gives an average area of 0.638 m^2. Equation 3 can be rearranged to give;

$$I = \frac{Fc}{A} \tag{4}$$

Therefore, giving an intensity of 1.65×10^{10} Wm^{-2}. The intensity of the light can be defined as the power (P) per area. This can be written as equation 5.

$$I = \frac{P}{A} \tag{5}$$

Now, the area in this equation is the surface area of the light source. For this discussion, the Sun is used as a reference. The surface area of the Sun is approximately 6.1×10^{18} m^2 [4]. Assuming the woman is at the average distance from the Sun (1.496×10^{11} m), the area of the shell of light radiating from the Sun will be 2.8×10^{23} m^2 [5]. Therefore, the power which would be needed to knock the woman, if provided by the Sun, would be 4.62×10^{33}W. This is an extraordinary amount, more than 12×10^6 times greater than the power provided by the Sun normally. The Sun ordinarily releases 3.846×10^{26}W of energy, although this is in the form of light and radiation energy [6].

The Stefan-Boltzmann law states that the total radiation emitted by a black body is proportional to its temperature to the power of four [1]. The assumption that the Sun can be considered a black body is now made. It can therefore be said that with the increase in power needed, the temperature would increase even more so. This is shown below;

$$Power \propto Temperature^4 \tag{6}$$

An increase in the Sun's temperature would understandably cause more damage than simply knocking someone backwards by 1 m. The temperature would be unbearable and this change would have drastic effects on the rest of the planet.

Conclusion

From using the average values of weight, height and width of a woman, the rate of energy per second (power) of the light required to knock her backwards by 1 m in 1 s was determined. The assumptions that the woman will have a rectangular surface area and there are no opposing forces working horizontally to her were made. The intensity of light required is said to be 1.65×10^{10} Wm^{-2} and the power, if provided by a source the same size as the Sun, would be 4.62×10^{33} W. This is 12×10^6 times greater than the power emitted by the Sun currently. Although many simplifications have been made, it successfully shows the ability to move an object with just light.

References

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