Work and Energy

Problem D

POTENTIAL ENERGY

PROBLEM

In 1993, Javier Sotomayor from Cuba set a record in the high jump by clearing a vertical distance of 2.45 m. If the gravitational potential energy associated with Sotomayor at the top point of his trajectory was 1.59×10^3 J, what was his mass?

SOLUTION

Given: $h = 2.45$ m

$g = 9.81$ m/s^2

$PE_g = 1.59 \times 10^3$ J

Unknown: $m = ?$

Use the equation for gravitational potential energy, and rearrange it to solve for *m*.

$$PE_g = mgh$$

$$m = \frac{PE_g}{gh}$$

$$m = \frac{(1.59 \times 10^3\ \text{J})}{\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)(2.45\ \text{m})} = 66.2\ \text{kg}$$

ADDITIONAL PRACTICE

1. **In 1992, Ukrainian Sergei Bubka used a short pole to jump to a height of 6.13 m. If the maximum potential energy associated with Bubka was 4.80 kJ at the midpoint of his jump, what was his mass?**
2. **Naim Suleimanoglu of Turkey has a mass of about 62 kg, yet he can lift nearly 3 times this mass. (This feat has earned Suleimanoglu the nickname of "Pocket Hercules.") If the potential energy associated with a barbell lifted 1.70 m above the floor by Suleimanoglu is 3.04×10^3 J, what is the barbell's mass?**
3. **In 1966, a special research cannon built in Arizona shot a projectile to a height of 180 km above Earth's surface. The potential energy associated with the projectile when its altitude was 10.0 percent of the maximum height was 1.48×10^7 J. What was the projectile's mass? Assume that constant free-fall acceleration at this altitude is the same as at sea level.**
4. **The highest-caliber cannon ever built (though never used) is located in Moscow, Russia. The diameter of the cannon's barrel is about 89 cm, and the cannon's mass is 3.6×10^4 kg. Suppose this cannon were lifted by airplane. If the potential energy associated with this cannon were 8.88×10^8 J, what would be its height above sea level? Assume that constant free-fall acceleration at this altitude is the same as at sea level.**

5. In 1987, Stefka Kostadinova from Bulgaria set a new women's record in high jump. It is known that the ratio of the potential energy associated with Kostadinova at the top of her jump to her mass was 20.482 m^2/s^2. What was the height of her record jump?

6. **In 1992, David Engwall of California used a slingshot to launch a dart with a mass of 62 g. The dart traveled a horizontal distance of 477 m. Suppose the slingshot had a spring constant of 3.0×10^4 N/m. If the elastic potential energy stored in the slingshot just before the dart was launched was 1.4×10^2 J, how far was the slingshot stretched?**

7. **Suppose a 51 kg bungee jumper steps off the Royal Gorge Bridge, in Colorado. The bridge is situated 321 m above the Arkansas River. The bungee cord's spring constant is 32 N/m, the cord's relaxed length is 104 m, and its length is 179 m when the jumper stops falling. What is the total potential energy associated with the jumper at the end of his fall? Assume that the bungee cord has negligible mass.**

8. **Situated 4080 m above sea level, La Paz, Bolivia, is the highest capital in the world. If a car with a mass of 905 kg is driven to La Paz from a location that is 1860 m above sea level, what is the increase in potential energy?**

9. **In 1872, a huge gold nugget with a mass of 286 kg was discovered in Australia. The nugget was displayed for the public before it was melted down to extract pure gold. Suppose this nugget is attached to the ceiling by a spring with a spring constant of 9.50×10^3 N/m. The nugget is released from a height of 1.70 m above the floor, and is caught when it is no longer moving downward and is about to be pulled back up by the elastic force of the spring.**

   a. If the spring stretches a total amount of 59.0 cm, what is the elastic potential energy associated with the spring-nugget system?

   b. What is the gravitational potential energy associated with the nugget just before it is dropped?

   c. What is the gravitational potential energy associated with the nugget after the spring has stretched 59.0 cm?

   d. What is the difference between the gravitational potential energy values in parts (b) and (c)? How does this compare with your answer for part (a)?

10. When April Moon set a record for flight shooting in 1981, the arrow traveled a distance of 9.50×10^2 m. Suppose the arrow had a mass of 65.0 g, and that the angle at which the arrow was launched was 45.0° above the horizontal.

    a. What was the kinetic energy of the arrow at the instant it left the bowstring?

    b. If the bowstring was pulled back 55.0 cm from its relaxed position, what was the spring constant of the bowstring? (Hint: Assume that all of the elastic potential energy stored in the bowstring is converted to the arrow's initial kinetic energy.)

    c. Assuming that air resistance is negligible, determine the maximum height that the arrow reaches. (Hint: Equate the arrow's initial kinetic energy to the sum of the maximum gravitational potential energy associated with the arrow and the arrow's kinetic energy at maximum height.)