Task

Answer the following questions. Show your working and include the correct units. Give your answers correct to 2 decimal places.

(g = 9.8 m/s^2 for the Earth)

1. A large pendulum has a bob of mass 1.2 kg which is raised by 2.2 m.

a Find the gain in its gravitational potential energy store.

b How much kinetic energy does it gain when it reaches the bottom? (Assume no energy is 'lost'.)

c What is the maximum speed the bob reaches when it reaches the bottom?

2. An elastic band with a spring constant of 1 240 N/m is stretched by 1.8 m.

a How much energy is stored in the elastic band?

b The elastic band is used to "fire" a ball bearing of mass 0.25 kg. How much kinetic energy will the ball bearing gain? (Assume no energy is 'lost'.)

c What is the maximum velocity the ball bearing will reach?

3. An elastic band with a spring constant of 1 600 N/m is stretched by 0.68 m.

a How much energy is stored in the elastic band?

b The elastic band is used to "fire" a ball bearing of mass 0.01 kg upwards. How much gravitational potential energy will the ball bearing gain? (Assume no energy is 'lost'.)

c What is the maximum height the ball bearing will reach?

4. A catapult is made using an elastic band with a spring constant of 360 N/m. It is used to fire a small ball of mass 45 g vertically into the air.

a If the elastic is stretched by 12 cm, how much energy does it store?

b Assuming no energy is "lost", how much gravitational potential energy does the ball gain?

c What height will the ball reach?

d Assuming no energy is "lost" as the ball falls back to Earth, how much kinetic energy will the ball gain?

e What speed will the ball be travelling at when it hits the ground?

5. When a tennis ball of mass 60 g hits the floor at 5 m/s.
How high will it bounce? (Assume that no energy is lost).

6. A toy gun uses a stretched spring to fire a foam dart of mass 15 g at a target. If the dart is to stick to the target, it must have a speed of at least 4.5 m/s.
If the spring has a spring constant of 66 N/m and it extends by 6 cm, will the dart stick to the target?

7. A roller coaster consists of 5 cars, each with a mass of 400 kg when fully loaded with people. The maximum drop on the ride is 60 m.
Use this information to determine the fastest speed the ride can achieve.

Extension

According to sources, "The Big One" in Blackpool, England, has a top speed of 74 miles per hour. Compare your answer to this. Is the answer you have for the above question a reasonable top speed for a roller coaster?

8. Shane says, "If I raise a bowling ball and a tennis ball to the same height, the bowling ball will gain more gravitational potential energy, because it has more mass, so when I drop it, it will reach a faster speed than the tennis ball because it will gain more kinetic energy." Use the equations for gravitational potential energy and kinetic energy to show that Shane is not correct.

Teaching notes and answers

The calculations relate the AQA specifications GCSE Trilogy, 6.1.1.2 and GCSE Physics, 4.1.1.2.

Students will need to have access to the Physics equation sheet so that they can select the equation $E_e = \frac{1}{2}ke^2$.

The other equations are ones that they will need to be able to recall.

1.
- **a.** 25.87 J
- **b.** 25.87 J
- **c.** 6.57 m/s

2.
- **a.** 2 008.80 J
- **b.** 2 008.80 J
- **c.** 126.77 m/s

3.
- **a.** 369.92 J
- **b.** 369.92 J
- **c.** 3 774.69 m

4.
- **a.** 2.59 J
- **b.** 2.59 J
- **c.** 5.87 m
- **d.** 2.59 J
- **e.** 10.73 m/s

5. 1.28 m

6. Dart will not stick. 0.1188 J of E_e given to the dart. Dart needs 0.151875 J to stick.

7. Carriage gains 1 176 000 J of E_p. It will reach 34.29 m/s. 74 mph = 32.8 m/s. Therefore a reasonable answer.

8. Assuming no energy is lost mgh = ½ mv^2,
m can be cancelled from each side to give gh = ½v^2
Therefore velocity is independent of mass.