WEBSITE PROBLEMS: **DYNAMICS**

Level 4

Exercise 1: A javelin thrower exerts a force on the javelin of 100 N for 0.3 s. A javelin weighs 800 grams. What is the rate of change of the momentum of the javelin?

a) 416.7 kg m s^{-2}

b) 333 kg m s^{-2}

c) 100 kg m s^{-2}

d) 30 kg m s^{-2}

e) 24 kg m s^{-2}

Adapted with permission from UCLES, A Level Physics, June 1989, Paper 1, Question 1.

Exercise 2: A wire that obeys Hooke's Law is of length l_1 when it is in equilibrium under a tension T_1, and its length becomes l_2 when the tension is increased to T_2. What is the extra energy stored in the wire as a result of this process?

a) $\frac{1}{4}(T_2 + T_1)(l_2 - l_1)$

b) $\frac{1}{4}(T_2 + T_1)(l_2 + l_1)$

c) $\frac{1}{2}(T_2 + T_1)(l_2 - l_1)$

d) $\frac{1}{2}(T_2 + T_1)(l_2 + l_1)$

e) $(T_2 - T_1)(l_2 - l_1)$

Used with permission from UCLES, A Level Physics, November 1987, Paper 1, Question 30.

Exercise 3: What is the power required to give a body of mass m a forward acceleration a when it is moving with velocity v up a frictionless track inclined at an angle θ to the horizontal?

a) $mavg\sin(\theta)$

b) $mav\sin(\theta) + mgv$

c) $mav + mgv\sin(\theta)$

d) $(mav + mgv)\sin(\theta)$

e) $\frac{mav+mgv}{\sin(\theta)}$

Used with permission from UCLES, A Level Physics, November 1988, Paper 1, Question 5.

Exercise 4: A surface is bombarded by particles, each of mass m, which have velocity v normal to the surface. On average, n particles strike a unit area each second and rebound elastically. What is the pressure on the surface?

a) nmv

b) $2nmv$

c) $\frac{1}{3}nmv^2$

d) $\frac{1}{2}nmv^2$

e) nmv^2

Used with permission from UCLES, A Level Physics, November 1989, Paper 1, Question 24.

Exercise 5: A block of wood weighing $M = 2.5$ kg is suspended from fixed pegs by vertical strings $l = 3$ m long, in a set up known as a ballistic pendulum. A bullet weighing $m = 10$ g and moving horizontally with a velocity $u = 300$ m s^{-1} enters and remains in the block. Find the angle through which the block swings.

Adapted with permission from UCLES, Higher School Certificate Physics, June 1929, Paper 2, Question 2.

Exercise 6:

a) When a car of mass 1000 kg is travelling along a level road at a steady 20 ms^{-1}, its engine is working at 18 kW. Find the total resistance due to friction, which may be taken to be constant.

b) The engine is suddenly disconnected and the brakes applied, and the car comes to rest in 50 m. Find the force, assumed constant, exerted by the brakes.

c) Find also the distance in which the car would come to rest if the engine were disconnected and the brakes applied on an upward incline of angle θ, where $\sin(\theta) = \frac{1}{20}$.

d) By how much does this change if the car is travelling down the same hill?

Adapted with permission from UCLES, A Level Applied Mathematics, June 1961, Paper 1, Question 2.

Exercise 7: A coil of rope of length $l = 10$ m and of mass $m = 1$ kg is lying on a horizontal floor. A man takes hold of one end and walks off at a speed $v = 5$ ms^{-1}, the rope uncoiling as he goes.

a) Neglecting friction, calculate the force he exerts on the rope.

b) When the whole rope has been started in motion, calculate:

   i. the kinetic energy acquired,

   ii. the work done by the man.

Comment on your result.

Adapted with permission from UCLES, Higher School Certificate Physics, June 1938, Paper 2.

Exercise 8: A rocket with initial mass M_0 and exhaust speed v is sitting on its launch pad. Its engines eject mass at a constant rate of magnitude $|\frac{\mathrm{d}M}{\mathrm{d}t}| = \mu$.

a) What is the initial acceleration, a_0 ?

b) Given that $M_0 = 1 \times 10^6$ kg, $v = 2000$ ms^{-1} and we require $a_0 = 0.5$ ms^{-2}, what must μ be?

Adapted with permission from HE+.

Exercise 9: Steel balls of mass $m = 0.1$ kg are dropped from a height of $h = 5$ m onto a smooth steel plate inclined at $\theta = 45°$ to the vertical. If the balls are dropped at the rate of $n = 100$ s^{-1}, what is the average force on the plate? You may assume that the collisions between the ball and the plate are elastic and that each ball hits the plate only once.

Adapted with permission from UCLES, Higher School Certificate Physics, June 1946, Paper 1.

Exercise 10: The 'spouting can', as shown in Figure 1, is sometimes used to demonstrate the variation of pressure with depth. When the corks are removed from the tubes in the side of the can, water of density ρ flows out with a speed that depends on depth.

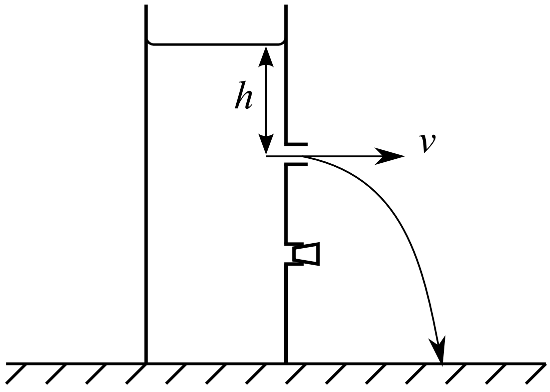

Figure 1

a) If the level of water in the can is maintained constant, calculate the work done by hydrostatic pressure when volume ΔV leaves a tube at a depth h below the surface.

b) Assuming that all this work provides the kinetic energy of the emerging water, show that the speed v of efflux (outflow) is $\sqrt{2gh}$.

c) In a certain can, the three tubes are set at equal distances a above the base of the can. When asked to draw the paths of the water coming from the three jets (the overall depth of the water being $4a$), a student made the sketch shown in Figure 2. Find the values of the distances x_1, x_2 and x_3 in terms of a, and sketch a better diagram.

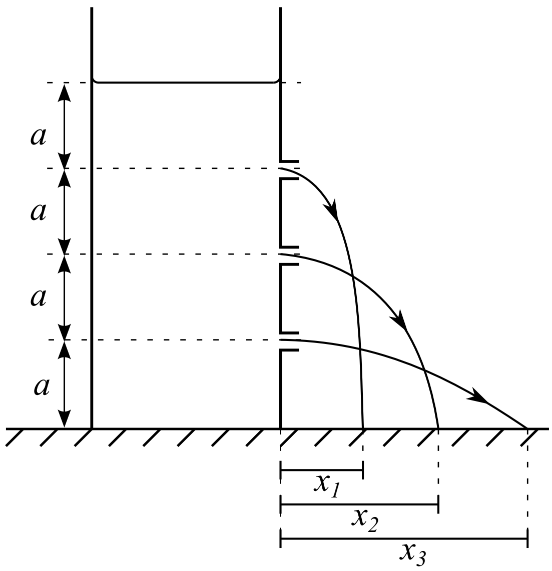

Figure 2

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