WEBSITE PROBLEMS: **DYNAMICS**

5 Level 5

Exercise 1: A car of mass m has an engine which can deliver power P. What is the minimum time in which the car can be accelerated from rest to speed v?

a) $\frac{mv}{P}$

b) $\frac{P}{mv}$

c) $\frac{mv^2}{2P}$

d) $\frac{2P}{mv^2}$

e) $\frac{mv^2}{4P}$

[*Used with permission from UCLES, A Level Physics, November 1986, Paper 1, Question 4.*]

Exercise 2: A light spring has a mass of 0.20 kg suspended from its lower end. A second mass of 0.10 kg is suspended from the first by a thread. The arrangement is allowed to come into static equilibrium and then the thread is burned through. At this instant, what is the upward acceleration of the 0.20 kg mass?

a) $0\,\mathrm{m\,s^{-2}}$

b) $3.2\,\mathrm{m\,s^{-2}}$

c) $4.9\,\mathrm{m\,s^{-2}}$

d) $6.6\,\mathrm{m\,s^{-2}}$

e) $9.8\,\mathrm{m\,s^{-2}}$

[*Used with permission from UCLES, A Level Physics, November 1987, Paper 1, Question 5.*]

Exercise 3: A car has a mass of 1000 kg and an engine capable of outputting a maximum power of 85 kW. When this car is travelling at a speed v it experiences a resistive force equal to $1.6v^2$ N.

The car is travelling at its maximum possible speed when it smashes into a brick wall, which brings it to an immediate halt. What impulse does the wall exert on the car?

a) $25700\,\mathrm{kg\,m\,s^{-1}}$

b) $37600\,\mathrm{kg\,m\,s^{-1}}$

c) $51400\,\mathrm{kg\,m\,s^{-1}}$

d) $75200\,\mathrm{kg\,m\,s^{-1}}$

e) $230000\,\mathrm{kg\,m\,s^{-1}}$

[*Created for the Rutherford School Physics Project by PS.*]

Exercise 4: A particle A has mass m and moves on a smooth plane inclined at an angle $\theta = 30°$ to the horizontal. Particle B, with mass $2m$, is attached to it by a light inextensible string running over a smooth pulley at the top of the slope. The system is held in position with B hanging vertically and the string taut. When the system is released, B falls a vertical distance x, causing A to move up the slope as in Figure **??**.

What is the speed of the particles after this motion?

a) $\sqrt{\frac{5}{3}gx}$

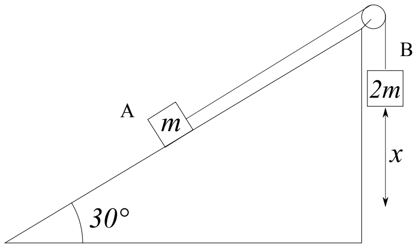

Figure 1

b) $\sqrt{\left(\frac{4+\sqrt{3}}{3}\right) gx}$

c) $\sqrt{\left(\frac{4-\sqrt{3}}{3}\right) gx}$

d) $\sqrt{gx}$

e) $\sqrt{\frac{1}{2}gx}$

[*Created for the Rutherford School Physics Project by PS.*]

Exercise 5: A horizontal jet of water with flow rate $Q = 500$ kg s^{-1} and moving at a speed $v = 4$ m s^{-1} strikes the tips of the blades of a water wheel. The blades are moving with half the speed of the water, and the water drops off with no horizontal velocity relative to the blades. Find the force exerted on the wheel.

[*Adapted with permission from UCLES, Higher School Certificate Physics, June 1931, Paper 2, Question 2.*]

Exercise 6:

a) A non-uniform rod of mass $m = 200$ kg and length $l = 10.0$ m has its centre of mass $d = 4.0$ m from one end. It is supported horizontally by two vertical ropes which are attached to points $s = 1.0$ m from each end. Calculate the tension in each rope.

b) The rod is raised by accelerating it at $a = 0.20$ m s^{-2} to a speed $v = 0.60$ m s^{-1}, which remains constant until the total height gained is $h = 12.0$ m, when the rod stops instantaneously. Calculate:

   i. the sum of the tensions in the ropes when the rod is accelerating,
   ii. the sum of the tensions in the ropes when the rod is moving up at a steady speed,
   iii. the power required when lifting the rod at v,
   iv. the distance for which the rod was accelerating and the distance for which it moved at v,

c) Using the above, or otherwise, find the work done raising the rod in terms of m, v and h. Comment on the value.

[*Adapted with permission from UCLES, A Level Additional Physics, November 1987, Paper 1, Question 1.*]

Exercise 7:

a) A long chain, with mass per unit length $\lambda = 1$ kg m^{-1}, is suspended vertically above a table by one end. The chain is allowed to fall, but held so that it always falls at $v = 5$ m s^{-1}. After $t = 5$ s what is the force exerted downwards on the table?

b) Now a chain with length $l = 5$ m is held above a table by one end, then allowed to fall freely under gravity. The moment the last piece of the chain touches the table, what is the total force being exerted on the table?

[*Used with permission from HE+.*]

Exercise 8: A hose pipe delivers a jet of water $d = 2$ cm in diameter, which impinges horizontally and normally on a side of a box weighing $m = 1$ kg, whose base rests in contact with a rough horizontal floor;

the coefficient of friction between the box and floor is $\mu = \frac{1}{2}$. Assuming that the water is of density $\rho = 1000$ kg m^{-3} and does not recoil from the box, determine the least velocity of the jet that will cause the box to move. [*Adapted with permission from UCLES, Higher School Certificate Mathematics, June 1931, Paper 3, Question 3.*]

Exercise 9: A heavy uniform chain hangs over a small smooth peg with equal lengths a on each side. Masses m and $3m$ are attached to the two ends, and the system is released from rest. Prove, by the principle of conservation of energy, that the mass m reaches the peg with velocity $\sqrt{ga}$, whatever the mass of the chain may be. [*Used with permission from UCLES, Higher School Certificate Applied Mathematics, June 1932, Question 7.*]

Exercise 10: Three identical particles A, B, and C are moving in a plane and, at time t, their position vectors with respect to an origin O are:

$$(2t+1)\underline{\boldsymbol{i}} + (2t+3)\underline{\boldsymbol{j}}$$
$$(10-t)\underline{\boldsymbol{i}} + (12-t)\underline{\boldsymbol{j}}$$
$$(t^3 - 15t + 4)\underline{\boldsymbol{i}} + (-3t^2 + 2t + 1)\underline{\boldsymbol{j}}$$

respectively.

a) Find the magnitude of the velocity of particle C relative to particle A when $t = 2$, and find the angle which this relative velocity makes with $\underline{\boldsymbol{i}}$ at this time.

b) Verify that particles A and B are both moving along the straight line with equation $y = x + 2$, and that they collide when $t = 3$.

c) Given that the collision between particles A and B is elastic, find the velocities of A and B immediately after the collision.

d) What are the position vectors of A and B a time τ after the collision?

[*Adapted with permission from UCLES, A Level Further Mathematics, Syllabus C, June 1988, Paper 4, Question 1.*]