PQ 10b Q and A

Q1

A 3 kg mass is moving at 6 m s^{-1}.

(a) Calculate its kinetic energy (E_K).

(b) Calculate the work required to change its speed to 12 m s^{-1}.

(c) If the work is done by a force of 2.5 N, calculate how far the mass moves while the force is acting.

(d) How long does this take?

(e) What power is developed by the force?

(a) $E_K = 0.5mv^2 = 0.5 \times 3 \times 6^2 = 54$ J

(b) $E_K = 0.5 \times 3 \times 12^2 = 216$ J

$W = 216 - 54 = +162$ J

(c) $W = Fs$; $162 = 2.5s$; $s = 64.8$ m

(d) $a = F/m = 2.5/3 = 0.83$ m s^{-2}

$t = v - u/a = 12 - 6/0.82 = 7.2$ s

(e) $P = W/t = 162/7.2 = 22.5$ W

Q2

A 0.25 kg toy car has 8 joules of E_K.

(a) Calculate its speed.

(b) How much work is required to be done to double the speed of the car?

(c) What force is required to stop the car over a distance of 6.4 m?

(d) How long will this take?

(e) What power is developed by the force?

(a) $v^2 = E_K/0.5m = 8/(0.5 \times 0.25) = 64$; $v = 8 \text{ m s}^{-1}$

(b) $E_K = 0.5 \times 0.25 \times 16^2 = 32 \text{ J}$

$W = (32 - 8) = 24 \text{ J}$

(c) $W = Fs$; $F = W/s = 8/6.4 = 1.25 \text{ N}$

(d) $a = F/m = 1.25/0.25 = 5 \text{ m s}^{-2}$

$t = (v - u)/a = (8 - 0)/5 = 1.6 \text{ s}$

(e) $P = W/t = 8/1.6 = 5 \text{ W}$

Q3

A 1.4 kg rock is fired from ground level straight up into the air at 5 m s^{-1}. Find:

(a) Its initial kinetic energy.

(b) How high above the ground it rises.

(c) Its gravitational potential energy at its highest point.

(d) The work gravity will do in returning the ball to the ground.

(a) $E_K = 0.5 \times 1.4 \times 5^2 = 17.5$ J

(b) $v^2 = u^2 + 2as$; $0 = 5^2 - 2 \times 9.8 \times s$; $s = 5^2/2 \times 9.8 = 1.275$ m

(c) $E_p = mgh = 1.4 \times 9.8 \times 1.275 = 17.5$ J

(d) $W =$ change in $E_p = 17.5$ J

Q4

An object moving at 3 m s^{-1} has 54 J of E_K.

(a) Calculate its mass.
(b) What work is done to stop this object?
(c) If the work is done by a constant frictional force of 2N, how far will it move while stopping?
(d) Find the acceleration of the object.
(e) How long will it take to stop?
(f) What power will the force develop in stopping the object?

(a) $m = E_K/0.5v^2 = 54/(0.5 \times 3^2) = 12$ kg
(b) $W = 54$ J
(c) $s = W/F = 54/2 = 27$ m
(d) $a = F/m = 2/12 = 0.16$ m s^{-2} against the motion
(e) $t = (v - u)/a = (3 - 0)/0.16 = 19$ s
(f) $P = W/t = 54/19 = 2.84$ W

Q5

Calculate the work required to stop each of the following moving objects.

(a) A 40 kg mass moving at 0.1 m s^{-1}.
(b) A 0.2 kg mass moving at 10 m s^{-1}.
(c) A 2 kg mass moving at 5 m s^{-1}.
(d) A 4.0 kg mass moving at 7 m s^{-1}.
(e) A 0.1 kg mass moving at 20 m s^{-1}.
(f) Each object is stopped by a force of 6 N. How far does each object move while stopping?

Q5 continued

(a) $W = 0.5 \times 40 \times 0.1^2 = 0.2$ J

(b) $W = 0.5 \times 0.2 \times 10^2 = 10$ J

(c) $W = 0.5 \times 2 \times 5^2 = 25$ J

(d) $W = 0.5 \times 4 \times 7^2 = 98$ J

(e) $W = 0.5 \times 0.1 \times 20^2 = 20$ J

(f) (a) $s = W/F = 0.2/6 = 0.033$ m

(b) $s = W/F = 10/6 = 1.67$ m

(c) $s = W/F = 25/6 = 4.16$ m

(d) $s = W/F = 98/6 = 16.33$ m

(e) $s = W/F = 20/6 = 3.33$ m

Q6

A 2 kg object, moving at 5 m s^{-1} accelerates until it reaches 15 m s^{-1}. This takes 4.0 s. Calculate:

(a) Its acceleration.

(b) The kinetic energy it gained.

(c) The work done on the object.

(d) How fast it would be moving if its E_K doubled from its value at 15 m s^{-1}.

(e) The extra work needed to be done to increase its speed from 15 m s^{-1} to 50 m s^{-1}.

(a) $a = (v - u)/t = (15 - 5)/4 = 2.5\text{ m s}^{-2}$

(b) Gain $E_K = 0.5 \times 2 \times 15^2 - 0.5 \times 2 \times 5^2 = 200\text{ J}$

(c) W = Gain in $E_K = 200\text{ J}$

(d) $2(0.5 \times 2 \times 15^2) = 0.5 \times 2 \times v^2$; $v^2 = 2 \times 15^2$; $v = 21.2\text{ m s}^{-1}$

(e) $W = 0.5 \times 2 \times 50^2 - 0.5 \times 2 \times 15^2 = 2275\text{ J}$

Q7

Calculate by how much the kinetic energy of an object changes if:

(a) Its mass doubles.
(b) Its mass triples.
(c) Its mass quadruples.
(d) Its speed doubles.
(e) Its speed triples.
(f) Its speed quadruples.

(a) E_K is proportional to m; $\times 2$
(b) $\times 3$
(c) $\times 4$
(d) E_K is proportional to v^2; $\times 4$
(e) $\times 9$
(f) $\times 16$

Q8

An engine develops 20 000 W of power in moving a 250 kg car against a frictional force of 500 N. This takes 4 s and the car moved a distance of 30 m. Find:

(a) The total work done.
(b) The work done against friction.
(c) The increase in the E_K of the car.
(d) The car's speed after the 4 s.

$W = 20000$ W; $m = 250$ kg; friction = 500 N; $t = 4$ s; $s = 30$ m

(a) $W = Pt = 20000 \times 4 = 80000 = 8 \times 10^4$ J

(b) $W = Fs = 500 \times 30 = 15000$ J

(c) Increase $E_K = 8 \times 10^4 - 1.5 \times 10^4 = 6.5 \times 10^4$ J

(d) $65000 = 0.5 \times 250 \times v^2$; $v^2 = 65000/0.5 \times 250$; $v = 22.8$ m s^{-1}

Q9

A 40 kg model car accelerates from rest to 20 m s^{-1} against a frictional force of 0.25 N kg^{-1}. This takes 8 s. Find:

(a) The acceleration of the car.
(b) The force causing the acceleration.
(c) The total force acting on the car.
(c) The work done on the car.
(d) How far the car travels.
(e) The work done against friction.
(f) The total work done by the force.
(g) The power developed by the car.

Q9 continued

$m = 40$ kg; $u = 0$; friction $= 0.25 \times 40 = 10$ N; $t = 8$ s

(a) $a = (20 - 0)/8 = 2.5$ m s^{-2} in the direction of the applied force

(b) $F = 40 \times 2.5 = 100$ N

(c) Total force $= 100 + 10 = 110$ N

(c) $W = 0.5 \times 40 \times 20^2 = 8000$ J

(d) $W = Fs$; $8000 = 100s$; $s = 80$ m

(e) $W = 10 \times 80 = 800$ J

(f) $W = 8000 + 800 = 8800$ J

(g) $P = 8800/8 = 1100$ W