Worked Solutions for ENGAA Papers by Topic

Section 2

Topic: Energy

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ENGAA S2 2020 - Question 7

7 A spaceship with mass 8.0×10^4 kg travels at constant velocity and has 1.0×10^{12} J of kinetic energy.

An external impulse of 8.0×10^7 kg m s^{-1}, lasting for 2.0 s, is applied to the spaceship acting in the opposite direction to the motion of the spaceship.

What is the average rate of loss of kinetic energy of the spaceship during the application of the impulse?

A 9.5×10^{10} W

B 1.8×10^{11} W

C 2.2×10^{11} W

D 3.2×10^{11} W

E 3.6×10^{11} W

F 7.2×10^{11} W

ENGAA S2 2020 - Question 7 - Worked Solution

$$T = \frac{1}{2}mv^2$$

$$\therefore v = \sqrt{\frac{2T}{m}} = 5000ms^{-1}$$

$$F = m\frac{v-u}{\Delta t}$$

$$F\Delta t = mv - mu$$

$$8\times10^7\times2 = 8\times10^9 \times \left(v_2 - 5000\right)$$

$$v_2 = 4000ms^{-1}$$

$$T' - T = \frac{1}{2}m\left(v_2^{\ 2} - v_1^{\ 2}\right)$$

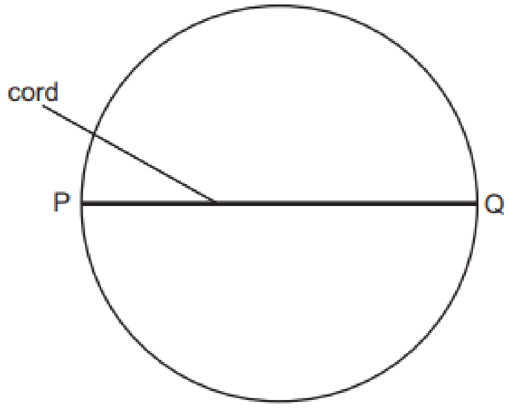
$$= -\ 3.6\times10^{11}J$$

$$P = \frac{\Delta T}{t} = \frac{-3.6\times10^{11}}{2s} = -\ 1.8\times10^{11}W$$

Answer is B

ENGAA S2 2020 - Question 13

13 An elastic cord with spring constant k is fixed to two points P and Q on the diameter of a ring so that the cord is taut but unstretched. The radius of the ring is r.



The midpoint of the cord is then pulled and fixed to a point on the ring halfway between P and Q.

What is the energy stored in the elastic cord?

A $\frac{1}{2}kr^2$

B $2kr^2$

C $\frac{1}{2}(\sqrt{2}-1)kr^2$

D $2(\sqrt{2}-1)kr^2$

E $\frac{1}{2}(3-2\sqrt{2})kr^2$

F $2(3-2\sqrt{2})kr^2$

ENGAA S2 2020 - Question 13 - Worked Solution

$$r' = \sqrt{r^2 + r^2}$$
$$= \sqrt{2}r$$
$$E = \frac{1}{2}k\Delta x^2 = \frac{1}{2}k\left(2\,.\,\sqrt{2}r - 2r\right)^2$$
$$.$$
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$$.$$
$$E = 2\left(3 - 2\sqrt{2}\right)kx^2$$

Answer is F

ENGAA S2 2017 - Question 3

3 Fig. 3(a) shows the results of an experiment in which a 0.5 m length of elastic cord has been extended by a force with a corresponding extension. The cord fails at point Q by fracture.

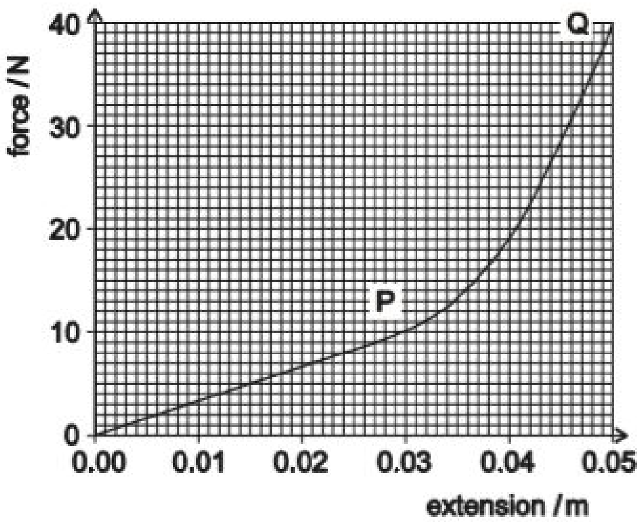

Fig. 3(a)

a) The elastic behaviour of a material can often be described by Hooke's law, which is given by the equation $F = kx$, where x is extension, F is force and k is an elastic constant which depends on the material studied.

Which of the following statements correctly describes the behaviour of the cord? **[2 marks]**

A no Hooke's law behaviour and fracture at a strain of 0.05

B Hooke's law behaviour up to P and fracture at a strain of 0.05

C Hooke's law behaviour up to Q and fracture at a strain of 0.05

D Hooke's law behaviour up to P and fracture at a strain of 0.1

E Hooke's law behaviour up to Q and fracture at a strain of 0.1

ENGAA S2 2017 - Question 3 - Worked Solution

a.

- $F \propto x$, so curd follows Hooke's law white graph is linear
- This is clearly the case up to point P
- The strain at fracture is.

$$strain = \frac{x}{length}$$
$$= \frac{0.05m}{0.5m}$$
$$= 0.1$$

Answer is D

b.

b) What is the work done U in stretching this 0.5 m length of elastic cord by 0.05 m (to 2 significant figures)? **[3 marks]**

A 0.15 J

B 0.30 J

C 0.60 J

D 2.0 J

E 6.0 J

Work done = area under graph

$$U = \frac{1}{2}\times 0.03\times 10 + 0.02\times 10 + \frac{1}{2}\times 0.02\times 30$$

$$U = 0.65$$

$$U = 0.6J$$

Answer is C

c.

c) An unstretched 0.25 m length of the same type of cord is used in a catapult to propel a mass m, as illustrated in Fig. 3(b).

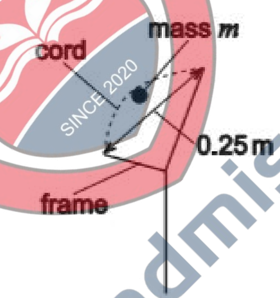

Fig. 3(b)

What is the maximum speed V_{max} at which the mass can be propelled (where U is the work done calculated in part **b)**)? **[3 marks]**

A $\sqrt{mU}$

B $\sqrt{\frac{U}{m}}$

C $\sqrt{\frac{2U}{m}}$

D $\sqrt{2mU}$

E $\sqrt{\frac{U}{2m}}$

- New cord has half the length of the old cord

- So the elastic potential energy the cord stores before snapping will also half
- So max e.p , e stored is U/2
- When catapulted , e.p e is transferred to kinetic energy

$$\frac{U}{2} = \frac{4}{2} m V_{max}^{2}$$

$$\frac{U}{m} = V_{max}^{2}$$

$$V_{max} = \sqrt{\frac{U}{m}}$$

Answer is B

d.

d) Two parallel 0.25 m lengths of the elastic cord are used in the catapult as shown in Fig. 3(c).

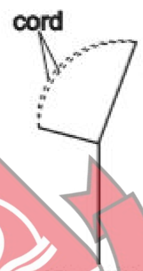

Fig. 3(c)

What is the maximum speed at which the mass can now be propelled? **[2 marks]**

A $\frac{1}{2} V_{max}$

B $\frac{1}{\sqrt{2}} V_{max}$

C V_{max}

D $\sqrt{2}\, V_{max}$

E $2V_{max}$

- Each cord stores $\frac{U}{2}$, so total EPE stored is U
- Now max speed is

$$U = \frac{1}{2} m V^{2}$$

$$V = \sqrt{\frac{2U}{m}}$$

$$V = \sqrt{2}\sqrt{\frac{U}{m}}$$

$$= \sqrt{2} V_{max}$$

Answer is D