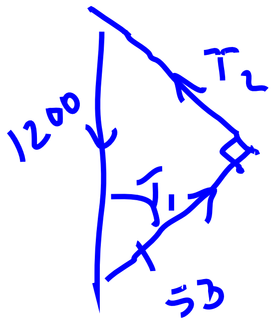
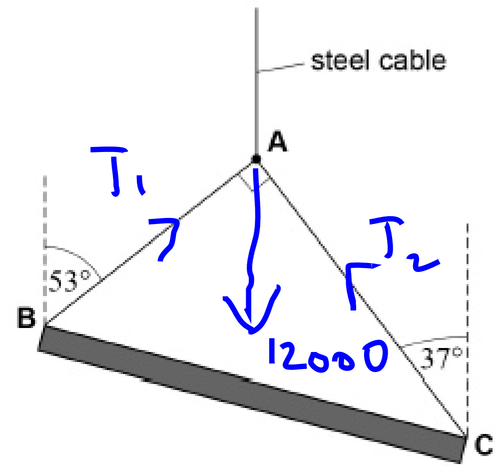
1 The diagram shows a uniform beam supported by two light cables, **AB** and **AC**, which are attached to a single steel cable from a crane. The beam is stationary and in equilibrium.





W = 1200

$T_1 = 12000 \cos 53$

$T_2 = 12000 \sin 53$

(a) State **two** necessary conditions for the beam to be in equilibrium.

Condition 1 sum of forces = 0

Condition 2 sum of moments = 0

(2)

(b) State what is meant by the centre of mass.

point where all the mass can be considered to act

(1)

(c) Explain why the centre of mass of the beam in the diagram must be vertically below **A**.

no resultant moment. A acts as the pivot point.

(2)

(d) The weight of the beam is 12 000 N

Calculate the tension T_1 in cable **AB** and the tension T_2 in cable **AC**.

See Fig 1

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T_1 = 7200 N

T_2 = 9600 N

(4)

(e) The steel cable from the crane has a circular cross-section of diameter 1.5×10^{-2} m
The cable is 12 m long.

Calculate the extension of the cable caused by the weight of the beam. You can assume that the weights of **all cables** are negligible.

Young modulus of steel = 2.0×10^{11} Pa

we are considering the single cable from the crane

ext

$$E = \frac{F/A}{e/L} \Rightarrow E = \frac{F}{A}\frac{L}{e} \Rightarrow \frac{FL}{AE} = e$$

$$\frac{12000 \times 12}{\pi\left(\frac{1.5\times10^{-2}}{2}\right)^2 \times 2.0\times10^{11}}$$

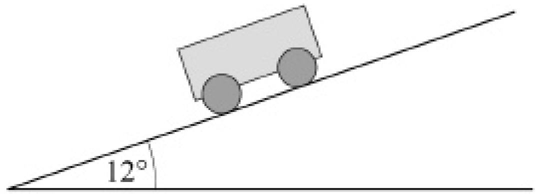
extension = 4.1×10^{-3} m

(3)

(Total 12 marks)

2 A car's engine produces a useful output power of 6.5×10^{4} W

The car of mass 950 kg is moving up a hill at a steady speed.
The slope of the hill is 12° to the horizontal. Resistive forces on the car are negligible.



What is the steady speed of the car?

A 7.0 m s^{-1} ⬭

B 12 m s^{-1} ⬭

C 34 m s^{-1} ⬭

D 68 m s^{-1} ⬭

(Total 1 mark)

3 A girl is bouncing on a trampoline.

Assuming that air resistance is negligible, her acceleration

A is zero when she is at maximum height. ⬭

B is constant when she is in the air. ⬭

C changes direction as she rises and then falls. ⬭

D is maximum just before she lands on the trampoline. ⬭

(Total 1 mark)

4 The table contains information on four wires. It shows the stiffness of each wire and the maximum strain energy stored in the wire when extended to the breaking point.

Assume each wire has the same initial dimensions and obeys Hooke's law.

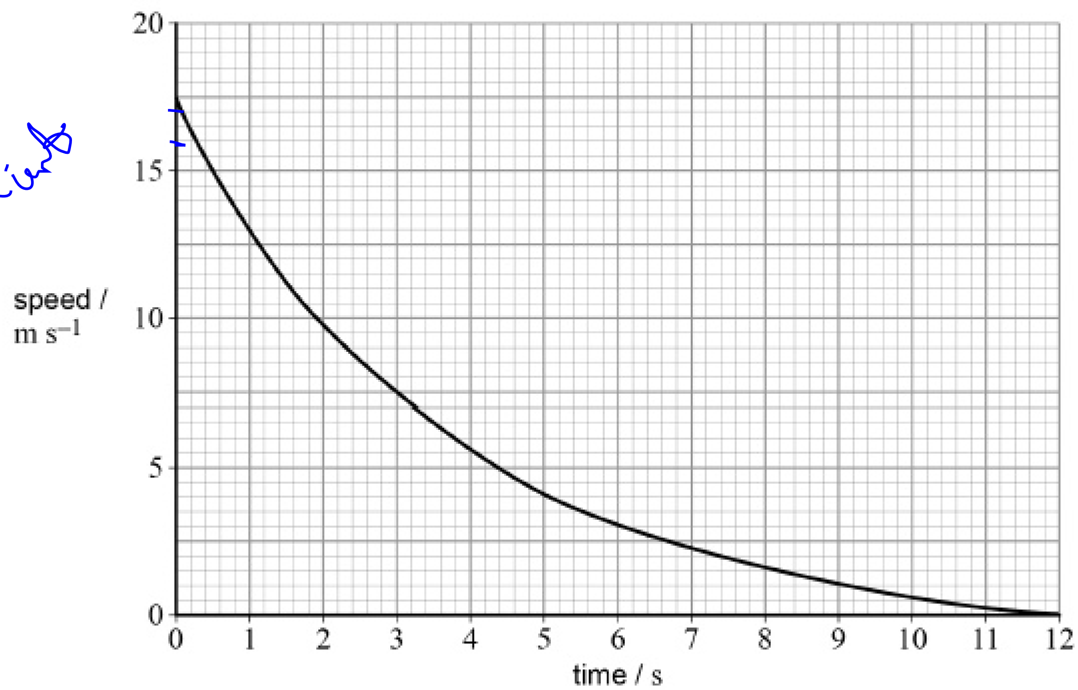
Which wire extends the least before reaching the breaking point?

	Stiffness / N m^{-1}	Maximum strain energy / J	
A	4.0	1	⬭
B	9.0	1	⬭
C	16	3	⬭
D	25	3	⬭

(Total 1 mark)

5 Horizontal escape lanes made of loose gravel have been constructed at the side of some roads on steep hills so that vehicles can stop safely when their brakes fail.

The graph shows an engineer's prediction of how the speed of an unpowered vehicle of mass 1.8×10^4 kg will vary with time as the vehicle comes to rest in an escape lane.



(a) Determine the force decelerating the vehicle 2.0 s after entering the escape lane.

force decelerating the vehicle = ____________________ N

(3)

(b) Deduce whether a lane of length 85 m is long enough to stop the vehicle, assuming that the engineer's graph is correct.

area under graph is distance

range = 50 – 60 m

So 85 is long enough

(3)

(c) Discuss the energy transfers that take place when a vehicle is decelerated in an escape lane.

Ek (or KE) is lost due to gravel being set into motion. So KE goes from lorry to gravel. If any gravel is sent upwards then there will be some transfer of KE to PE as well

(2)

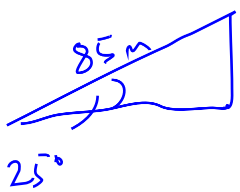
(d) An alternative to an escape lane containing gravel is an escape lane that consists of a ramp. An escape ramp is a straight road with a concrete surface that has a constant upward gradient.

One escape ramp makes an angle of 25° to the horizontal and is 85 m long.

Deduce whether this escape ramp is sufficient to stop the vehicle.

$\sin\theta = o/h$

Assume that any frictional forces and air resistance that decelerate the vehicle are negligible.



So we need $\Delta y = 85\sin 25 = 36$ m

$m = 1.8\times10^4$ Kg ∴ max PE gain on ramp $= 6.4\times10^6$ J

$V_{initial} = 17.5$ ∴ $E_k = \frac{1}{2}\times1.8\times10^4\times(17.4)^2$

$2.7(2)\times10^6$ J

So yes

(3)

(e) Discuss whether an escape lane containing gravel or an escape ramp would provide the safer experience for the driver of the vehicle as it comes to rest.

I think gravel because you are likely to be somewhat out of control, and you don't want to go off the edge/top of a ramp... but leavint that to one side because the question says 'comes to rest' so perhaps they are after a 'safe' stop....

In which case I'd say the ramp because would be deceleration would be constant as energy is lost uniformly. The gravel might also cause skidding

(1)

(Total 12 marks)

6 The diagram shows two railway trucks **A** and **B** travelling towards each other on the same railway line which is straight and horizontal.

The trucks are involved in an inelastic collision. They join when they collide and then move together.

The trucks move a distance of 15 m before coming to rest.

Truck **A** has a total mass of 16 000 kg and truck **B** has a total mass of 12 000 kg

Just before the collision, truck **A** was moving at a speed of 2.8 m s^{-1} and truck **B** was moving at a speed of 3.1 m s^{-1}

(a) State the quantity that is **not** conserved in an inelastic collision.

kinetic energy... not just energy

(1)

(b) Show that the speed of the joined trucks immediately after the collision is about 0.3 m s^{-1}

← going in opposite direction

$2.8 \times 16000 - 3.1 \times 1200 = 28000 \times v$

so $v = 0.27 \approx 0.3$ m/s

(3)

(c) Calculate the impulse that acts on each truck during the collision.
Give an appropriate unit for your answer.

impulse $= F\Delta t = \Delta(mv) = m(v-u)$

$I_A = 16000(2.8 - 0.27) = 40480$

impulse = 41 000 unit Ns

(2)

(d) Explain, without doing a calculation, how the motion of the trucks immediately after the collision would be different for a collision that is perfectly elastic.

Each truck would change direction -not stick together

so mom of A before = mom of b after

Orriginal mom is to the right - this has to be conservered and since A has a small mass it must have a larger velocity,

(2)

(Total 8 marks)