Q1

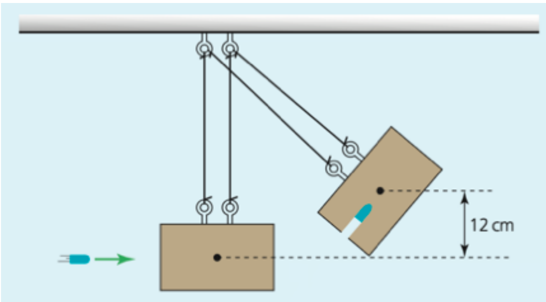
Figure shows an experiment to measure the speed of a bullet which was fired into a block of wood. The bullet is embedded in the wood, so this was a totally inelastic collision. The block of wood and the bullet had kinetic energy and this was transferred to gravitational potential energy as they swung upwards.

a Outline what is meant by a totally inelastic collision.

b If the combined mass of the block and the bullet was 1.23 kg, determine their maximum gravitational potential energy.

c Use the law of conservation of energy to show that the initial velocity of the combined block and bullet was 1.5 m s^{-1}

d. the bullet's mass was 15 g, use the law of conservation of momentum to determine its speed.



a) colliding masses stick together

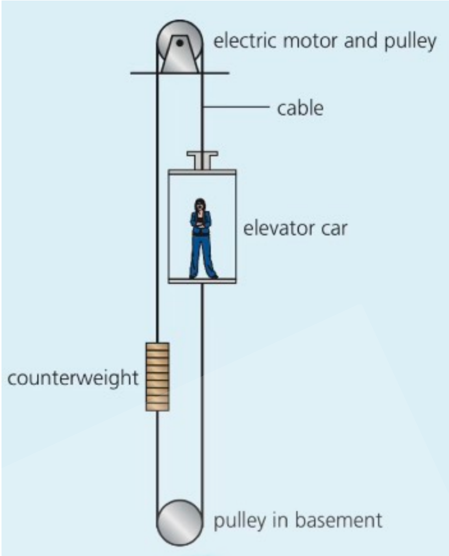
b) $E_g = mgh$
$= 1.23 \times 9.81 \times 0.12$
$= 1.45\ J$

c) $T_{E(B)} = T_{E(A)}$
$mgh + \frac{1}{2}mv^2 = mgh + \frac{1}{2}mv^2$
$= 0 + \frac{1}{2}(1.23) \cdot v^2 = 1.45 + 0$
$v = 1.53\ m/s$

d) $P_B = P_A$
$P_{Bl} + P_{Bu} = P_{Bl} + P_A$
$0 + 0.015 \times v = 1.23 \times 1.53$
$v = 125.46\ m/s$

Bl = Block
Bu = Bullet

Q2



An elevator (lift) which has a mass of 2400 kg when empty is connected (as shown in Figure.) to a counterweight of the same mass.
When the elevator goes up, the counterweight goes down. Five people of total mass 265 kg got in the elevator and went up four floors, each floor of height 3.2 m.

a Outline the reason for using a counterweight.

b Calculate the useful work done by the motor.

c If, in fact, 1.3×10^5
J of energy was transferred from
the electrical supply to the motor, determine the efficiency of the process.

d If the process took a total time of 18 s, what was the average input power to the motor?

e How much energy was transferred in overcoming friction?

f Discuss where friction would occur in this system.

a) It Reduces the load on motor, because the motor will have to lift the load equal to difference of mass.

b) $W = F \times d$
$= 265 \times 9.81 \times (4 \times 3.2)$
$= 3.3 \times 10^4$ J

c) $\eta = \frac{\text{output}}{\text{input}} \times 100$
$= \frac{3.3 \times 10^4}{1.3 \times 10^5} \times 100 = 0.2531$
$= 25\%$

d) $P = \frac{E}{t} = \frac{1.3 \times 10^5}{18} = 7222.22$ W
$= 7.2 \times 10^3$ W

e) $1.3 \times 10^5 - 3.3 \times 10^4$
$= 9.7 \times 10^4$ J

f Pully, electric motor.

Q3

An airplane has a mass of 200 tonnes (2.0×10^5 kg) and take-off speed of 265 km h^{-1} (73 m s^{-1}) at the end of a distance of 2.24 km from where it began.

a Calculate the kinetic energy of the airplane when it takes off.

b Estimate the average power output from the airplane's engines while it is on the runway.

c What average resultant forward force was acting on the airplane during its movement along the runway?

d If 76 kg of fuel was used during take off, calculate the efficiency of the process if 1 kg of fuel can transfer 43 MJ.

a) $E_K = \frac{1}{2} m v^2$

$= \frac{1}{2} (2 \times 10^5) \times (73)^2$

$= 5329 \times 10^5 = 5.3 \times 10^8$ J

b) $P = \frac{E}{t} =$ for time $\left(\frac{v+u}{2}\right) t = s$

$= \left(\frac{73+0}{2}\right) t = 2240$

$t = 61.37$ s.

$P = \frac{5.3 \times 10^8}{61.37}$

$= 8.6 \times 10^6$ W

c) $P = F \times v$

$8.6 \times 10^6 = F \times \left(\frac{73+0}{2}\right)$

$F = 2.4 \times 10^5$ N

d) Energy transferred $= 43 \times 10^6 \times 76$

$= 3268 \times 10^6$ J.

$\eta = \frac{5.3 \times 10^8}{3.3 \times 10^9} \times 100$

$= 16\%$

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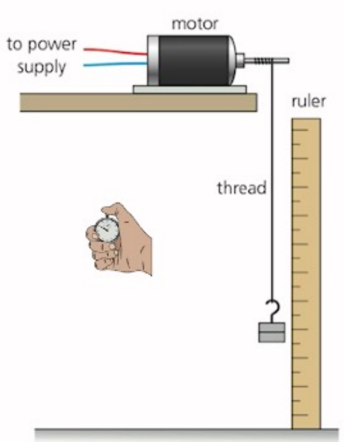
Q4

Figure shows an experiment designed to measure the efficiency of a small electric motor. Electrical power was supplied to the motor at a rate of 0.72 W. The hanging mass (25 g) went up a distance of 1.12 m in 2.46 s.



a Calculate how much gravitational potential energy was transferred to the mass.

b How much electrical energy was transferred in this time?

c Determine the efficiency of the motor.

d How much energy was dissipated into the surroundings?

e State the forms of this dissipated energy.

a) $E_g = mgh = 0.025 \times 9.81 \times 1.12$
$= 0.27\ J.$

b) $P = \frac{E}{t}$ $E = P \times t$
$= 0.72 \times 2.46$
$= 1.77\ J \approx 1.8\ J$

c) $\eta = \frac{E_{out}}{E_{in}} \times 100$
$= \frac{0.27}{1.77} \times 100 = 15\%$

d) $1.77 \times 0.27 = 1.5\ J$

e) Thermal / sound energy.

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Q5

An oil burning power station has an efficiency of 39% and an output of 770 MW.

a Calculate the mass of oil burned:

i every second

ii every year.

b Estimate how much reactor grade uranium-235 would be needed every year to produce the same output power (assume the same efficiency).

a) $\eta = \frac{\text{output}}{\text{Input}} \times 100$

$\text{Input} = \frac{770 \times 10^6}{0.39} = 1974 \text{ MW}$

$\Rightarrow$ In 1 second 1974 MJ of Energy is supplied.

Specific Energy = 37000 MJ/m³

$\Rightarrow$ In 1 second, Quantity burned

$= \frac{1974}{37000} = 0.0533 \text{ m}^3$

$\Rightarrow$ In 1 year $= 0.0533 \times 60 \times 60 \times 24 \times 365$

$= 1.68 \times 10^6 \text{ m}^3$

b) Specific Energy of Uranium $= 6.6 \times 10^{10}$ MJ/m³.

$\therefore$ U-235 needed every year $= \frac{1974}{6.6 \times 10^{10}} \times 60 \times 60 \times 24 \times 365$

$= 0.94 \text{ m}^3$.

Reference - Hodder IBDP physics