SQ 4.1 Why is electrical power required when an elevator is descending? Why should there be a limit on the number of passengers in this case?

During descent, the motor does work against friction and controls the downward motion.
Therefore, electrical power is required.
More passengers increase the weight and the work to be done by the motor.
Hence, passengers must be limited according to the power and safe load of the motor.

SQ 4.2 A body is being raised to a height H from the surface of the Earth. What is the sign of work done by both the body and the Earth? Justify.

Work done on the body is positive because force and displacement are in the same direction.
Work done by the Earth is negative because gravitational force is opposite to displacement.

$$W = Fd\cos 180^\circ = -mgH$$

SQ 4.3 A body falls towards the Earth in air. Will its total mechanical energy be conserved during the fall? Justify.

No, its mechanical energy is not conserved.
Air resistance is a non-conservative force.
A part of P.E. is used in doing work against air friction.
The remaining P.E. is converted into K.E.

$$\text{Loss in P.E.} = \text{Gain in K.E.} + \text{Work done against friction}$$

SQ 4.4 Calculate the power of a crane in kilowatts which lifts a mass of $1000\,\mathrm{kg}$ to a height of $100\,\mathrm{m}$ in $20\,\mathrm{s}$.

Given

$m = 1000\,\mathrm{kg}$
$h = 100\,\mathrm{m}$
$t = 20\,\mathrm{s}$

Work done

$$W = mgh = (1000)(9.8)(100) = 9.8 \times 10^5\,\mathrm{J}$$

Power

$$P = \frac{W}{t} = \frac{9.8 \times 10^5}{20} = 49\,\mathrm{kW}$$

SQ 4.5 A trolley of mass $1500\,\mathrm{kg}$ carrying $500\,\mathrm{kg}$ of sand moves uniformly at $40\,\mathrm{km\,h^{-1}}$ on a frictionless track. Sand leaks vertically at $0.05\,\mathrm{kg\,s^{-1}}$. What is the trolley speed after all the sand has leaked out?

No external horizontal force acts on the trolley.
The leaking sand has the same horizontal velocity as the trolley at the instant it falls.
Therefore, the trolley continues with the same speed.

$$v = 40\,\mathrm{km\,h^{-1}}$$

SQ 4.6 Give the absolute and gravitational units of work in M.K.S. and C.G.S. systems.

M.K.S. absolute unit: joule ($\mathrm{N\,m}$).
M.K.S. gravitational unit: kilogram-force metre ($\mathrm{kgf\,m}$).
C.G.S. absolute unit: erg ($\mathrm{dyn\,cm}$).
C.G.S. gravitational unit: gram-force centimetre ($\mathrm{gf\,cm}$)

$$1\,\mathrm{J} = 10^7\,\mathrm{erg}$$

SQ 4.7 A body dropped from a height H reaches the ground with speed $1.2\sqrt{gH}$. Calculate the work done by air friction.

Apply the energy relation

Loss in P.E. = Gain in K.E. + work against friction

Therefore

$$mgH = \frac{1}{2}m(1.2\sqrt{gH})^2 + W_f$$

$$W_f = 0.28mgH$$

Work done against air friction is $0.28mgH$.
Work done by air friction is $-0.28mgH$.

SQ 4.8 A bicycle has kinetic energy of $150\,\mathrm{J}$. What kinetic energy would it have if it had (i) the same mass but double the speed, and (ii) three times the mass and one-half the speed?

Relation

$$K.E. = \frac{1}{2}mv^2$$

(i) Same mass and double speed

$$K.E.' = 4(K.E.) = 600\,\mathrm{J}$$

(ii) Three times mass and one-half speed

$$K.E.' = \frac{3}{4}(K.E.) = 112.5\,\mathrm{J}$$

SQ 4.9 What is the effect on the kinetic energy of a body of mass m moving with velocity v when its momentum becomes double? Justify.

Since

$$p = mv$$

double momentum means double velocity for constant mass.

$$K.E.' = \frac{1}{2}m(2v)^2 = 4\left(\frac{1}{2}mv^2\right)$$

Hence, the K.E. becomes four times.

SQ 4.10 Does the International Space Station have gravitational potential energy, kinetic energy, or both? Explain.

The International Space Station possesses both K.E. and gravitational P.E.
It has K.E. due to its orbital motion.
It has P.E. due to its position in the gravitational field of the Earth.

CRQ 4.1 When is a force said to be conservative? Give two conditions.

A force is conservative if its work between two points is independent of the path followed.
Condition 1: Work done between two points is path independent.
Condition 2: Work done in a closed path is zero.

CRQ 4.2 **A light body and a heavy body have the same linear momentum. Which one has greater kinetic energy?**

Relation

$$K.E. = \frac{p^2}{2m}$$

For the same momentum, K.E. is inversely proportional to mass.
Therefore, the light body has greater K.E.

CRQ 4.3 **A motorcycle moves with constant speed on a horizontal track. Is any work being done on it if no net force acts on it?**

According to the work-energy theorem

$W = \text{change in K.E.}$

Constant speed means constant K.E.
Therefore, no net work is done on the motorcycle.

CRQ 4.4 **A force acts on a ball moving at $14\,\mathrm{m\,s^{-1}}$ and reduces its speed to $6\,\mathrm{m\,s^{-1}}$. Has the force done positive or negative work? Explain.**

Apply the work-energy theorem

$$W = (K.E.)_f - (K.E.)_i$$

$$W = \frac{1}{2}m(6^2 - 14^2) = -80m\,\mathrm{J}$$

The work is negative because the K.E. of the ball decreases.

CRQ 4.5 **A slow-moving truck can have more kinetic energy than a fast-moving car. How is this possible?**

K.E. depends upon mass and the square of velocity.

$$K.E. = \frac{1}{2}mv^2$$

The mass of a truck is much greater than that of a car.
Therefore, a slow-moving truck may possess greater K.E.

CRQ 4.6 **Why is work done against friction non-conservative in nature? Explain briefly.**

Kinetic friction always acts opposite to motion and does negative work.
Its work depends upon the length of the path.
A greater amount of work is done over a longer path.
Work done in a closed path is not zero.
Therefore, friction is non-conservative.

CRQ 4.7 **Does wind contain kinetic energy? Explain.**

Yes, wind contains kinetic energy.
Wind is air in motion, and air has mass and velocity.

$$K.E. = \frac{1}{2}mv^2$$