# WORK-ENERGY-POWER

**1** Two workmen are employed on a building project, as shown in Fig. 5.1.

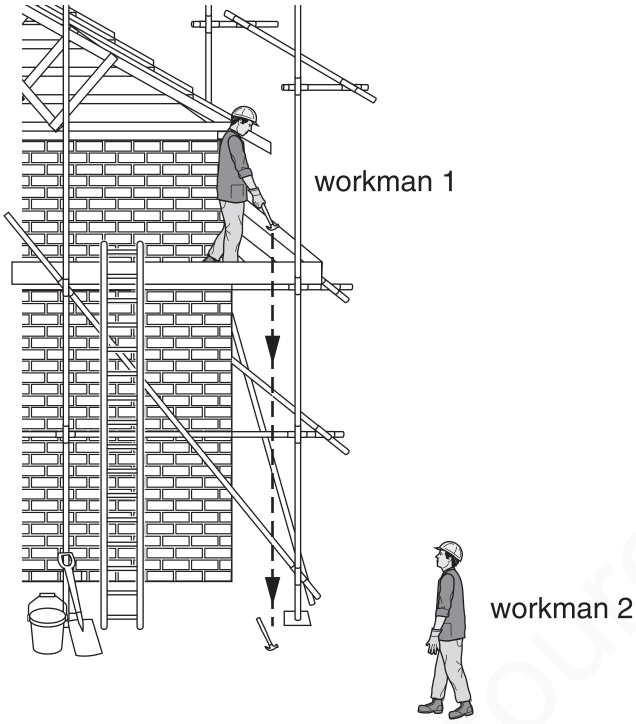


**Fig. 5.1**

**(a)** Workman 1 drops a hammer, which falls to the ground. The hammer has a mass of 2.0 kg, and is dropped from a height of 4.8 m above the ground.

**(i)** Calculate the change in gravitational potential energy of the hammer when it is dropped.

change in gravitational potential energy = .......................................................[2]

**(ii)** Describe the energy changes from the time the hammer leaves the hand of workman 1 until it is at rest on the ground.

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

.......................................................................................................................[2]

**(b)** Workman 2 picks up the hammer and takes it back up the ladder to workman 1.

He climbs the first 3.0 m in 5.0 s. His total weight, including the hammer, is 520 N.

**(i)** Calculate the useful power which his legs are producing.

power = ........................................................[2]

**(ii)** In fact his body is only 12% efficient when climbing the ladder.

Calculate the rate at which energy stored in his body is being used.

rate = ........................................................[1]

[Total: 7]

MARKING SCHEME:

| | | | |
|---|---|---|---|
| **(a) (i)** | *mgh* in any form OR 2.0 × 10 × 4.8 | C1 | |
| | 96 J | A1 | |
| **(ii)** | GPE → KE (+ heat and/or sound)<br>→ heat and/or sound<br>–1 e.e.o.o. | B2 | |
| **(b) (i)** | force × distance/time OR 520 × 3/5 | C1 | |
| | 312 W | A1 | |
| **(ii)** | 2600 W ecf **(i)** | B1 | [7] |

**2** **(a)** State what is meant by the *centre of mass* of a body.

..........................................................................................................................................

..........................................................................................................................................

.................................................................................................................................... [1]

**(b)** Fig. 4.1 shows an athlete successfully performing a high jump.

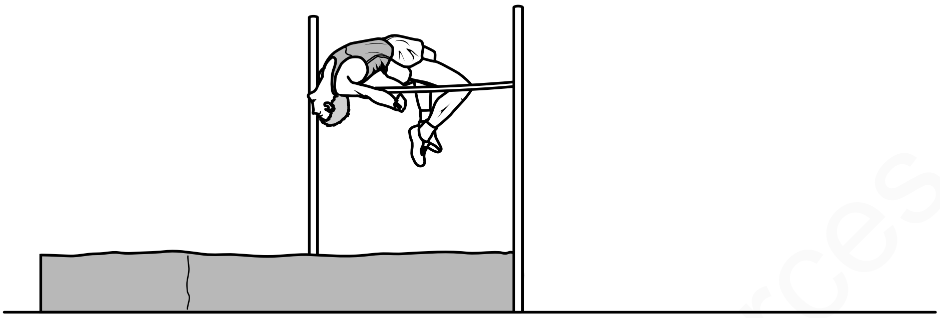

**Fig. 4.1**

The height of the bar above the ground is 2.0 m. The maximum increase in gravitational potential energy (g.p.e.) of the athlete during the jump is calculated using the expression g.p.e. = $mgh$.

Explain why the value of $h$ used in the calculation is much less than 2.0 m.

..........................................................................................................................................

..........................................................................................................................................

.................................................................................................................................... [1]

**(c)** Fig. 4.2 shows, in order, five stages of an athlete successfully performing a pole-vault.

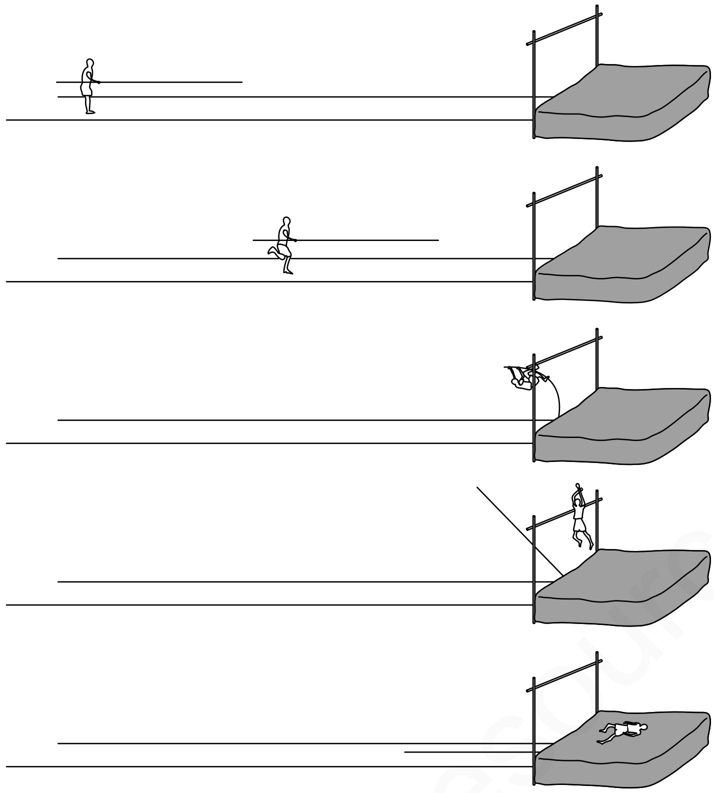

**Fig. 4.2**

Describe the energy changes which take place during the performance of the pole-vault, from the original stationary position of the pole-vaulter before the run-up, to the final stationary position after the vault.

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

.................................................................................................................................... [6]

[Total: 8]

MARKING SCHEME:

**(a)** (The point in the body) where (all) the mass / weight / gravity acts / appears to act (owtte) B1

**(b)** h is the height through which the centre of mass/rises
OR centre of mass/rises (much) less than 2.0 m

OR centre of mass/of athlete is above the ground level
OR centre of mass/gravity passes under bar B1

Allow centre of gravity in place of centre of mass

**(c)** Standing: has chemical energy B1
Run-up: kinetic energy gained B1
Pole bent: has strain / elastic energy B1
Rise: potential energy gained B1
Fall: kinetic energy gained B1
On mat: has thermal / heat / sound / strain / elastic energy B1 **[8]**

**3** Fig. 3.1 shows an aeroplane of mass $3.4 \times 10^5$ kg accelerating uniformly from rest along a runway.

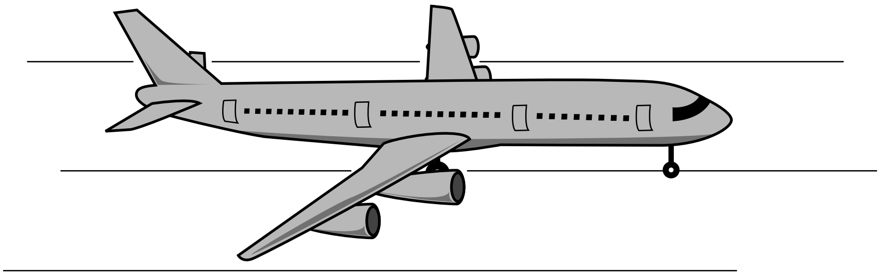

**Fig. 3.1**

After 26 s it reaches a speed of 65 m/s.

**(a)** Calculate

**(i)** the acceleration of the aeroplane,

acceleration = ................................................. [2]

**(ii)** the resultant force on the aeroplane.

force = ................................................. [2]

**(b)** Just after taking off, the aeroplane continues to accelerate as it gains height.

**(i)** State **two** forms of energy that increase during this time.

1. ........................................................................................................................

2. ........................................................................................................................ [2]

**(ii)** State **one** form of energy that decreases during this time.

........................................................................................................................ [1]

**(iii)** State why the total energy of the aeroplane decreases during this time.

........................................................................................................................

........................................................................................................................ [1]

**(c)** When the aeroplane reaches its maximum height, it starts to follow a curved path at a constant speed.

State the direction of the resultant force on the aeroplane.

........................................................................................................................ [1]

MARKING SCHEME:

| | | | | |
|---|---|---|---|---|
| **(a)** | **(i)** | (a =) v/t **or** 65/26 | | C1 |
| | | 2.5 m/$s^2$ *Unit penalty applies | | A1 |
| | **(ii)** | (F =)ma **or** 3.4 × $10^5$ × 2.5 | ecf from **3(a)(i)** | C1 |
| | | 8.5 × $10^5$ N *Unit penalty applies | ecf from **3(a)(i)** | A1 |
| **(b)** | **(i)** | any <u>two</u> of: KE **or** GPE **or** heat/internal energy/thermal energy | | B2 |
| | **(ii)** | chemical energy **not** heat | | B1 |
| | **(iii)** | thermal energy/sound is lost (to the atmosphere) **or** KE <u>of air</u> | | B1 |
| **(c)** | | perpendicular to path **or** towards centre of circle **or** centripetal | | B1 **[9]** |

*Apply unit penalty once only

**4** **(a)** State the energy changes that take place when

**(i)** a cyclist rides down a hill without pedalling,

..........................................................................................................................

..........................................................................................................................

**(ii)** a cyclist pedals up a hill at a constant speed.

..........................................................................................................................

..........................................................................................................................
[3]

**(b)** A car of mass 940 kg is travelling at 16 m / s.

**(i)** Calculate the kinetic energy of the car.

kinetic energy = ................................................. [2]

**(ii)** The car is brought to rest by applying the brakes.

The total mass of the brakes is 4.5 kg. The average specific heat capacity of the brake material is 520 J / (kg °C).

Calculate the rise in temperature of the brakes. Assume there is no loss of thermal energy from the brakes.

rise in temperature = ................................................. [3]

[Total: 8]

MARKING SCHEME:

| | | | |
|---|---|---|---|
| **(a)** | **(i)** | (gravitational) potential energy to kinetic energy | B1 |
| | **(ii)** | chemical energy to (gravitational) potential energy | B1 |
| | | reference in **(i)** or **(ii)** to heat/thermal/internal energy produced OR work done against air resistance or friction | B1 |
| **(b)** | **(i)** | (K.E. =) $\frac{1}{2}mv^2$ OR $0.5 \times 940 \times 16^2$ | C1 |
| | | $1.2 \times 10^5$ J | A1 |
| | **(ii)** | in words or symbols $Q = mc\theta$ OR $\theta = Q/mc$ | C1 |
| | | $1.203 \times 10^5 = 4.5 \times 520 \times \theta$ OR $\theta = 1.203 \times 10^5 / (4.5 \times 520)$ | C1 |
| | | 51 °C or K | A1 |

**[Total: 8]**

**5** Fig. 3.1 shows a fork-lift truck lifting a crate on to a high shelf in a warehouse.

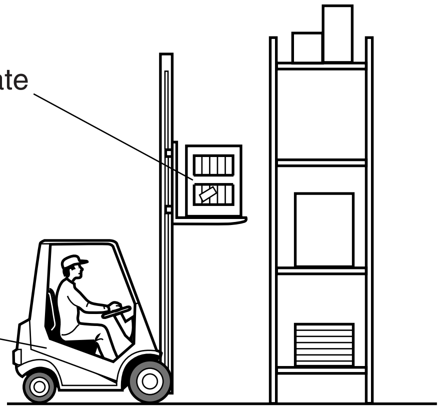


**Fig. 3.1**

The fork-lift truck lifts a crate of weight 640 N through a vertical distance of 3.5 m in 4.0 s.

**(a)** Calculate the useful work done in lifting the crate.

work done = ................................................ [2]

**(b)** A motor drives a mechanism to lift the crate. The current in the motor is 25 A. The motor is connected to a 75 V battery.

Calculate

**(i)** the energy supplied to the motor in 4.0 s,

energy = ................................................ [2]

**(ii)** the overall efficiency of the fork-lift truck in lifting the crate.

efficiency = ................................................ [2]

 

**(c)** Not all of the energy supplied is used usefully in lifting the crate.

Suggest two mechanisms by which energy is wasted.

1. ..........................................................................................................................

2. .......................................................................................................................... [2]

[Total: 8]

MARKING SCHEME:

| | | | |
|---|---|---|---|
| **(a)** | (W.D. =) $F \times d$ **or** 640 × 3.5 | C1 | |
| | 2240 J to 2 or more sig. figs. | A1 | [2] |
| **(b) (i)** | ($E$ =) $VIt$ **or** 75 × 25 × 4.0 **or** 75 × 100 (accept ($E$ =) $VQ$ and $Q = It$) | C1 | |
| | 7500 J | A1 | [2] |
| **(ii)** | (efficiency =) $\frac{\text{(useful) energy output}}{\text{energy input}}$ (× 100%) **or** 2240/7500 | | |
| | (accept power for energy) (e.c.f. from **3(a)(i)** or **3(b)(i)**) | C1 | |
| | 0.3 or 0.30 or 0.299 or 30% or 29.9% (e.c.f. from **3(a)(i)** or **3(b)(i)**) | A1 | |
| **(c)** | any **two** from:<br>electrical heating<br>friction<br>W.D. lifting supports<br>sound | B2 | [2] |

**[Total: 8]**

**6** A diver climbs some steps on to a fixed platform above the surface of the water in a swimming-pool.

He dives into the pool. Fig. 2.1 shows the diver about to enter the water.

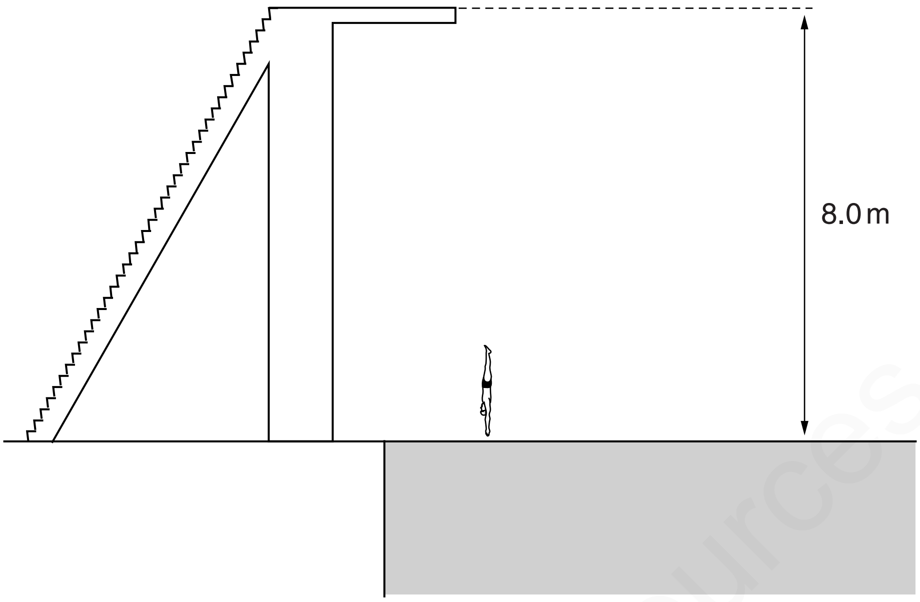


**Fig. 2.1**

The mass of the diver is 65 kg. The platform is 8.0 m above the surface of the water.

**(a)** Calculate

**(i)** the increase in the gravitational potential energy of the diver when he climbs up to the platform.

increase in gravitational potential energy = ................................................[1]

**(ii)** the speed with which the diver hits the surface of the water. Ignore any effects of air resistance.

speed = ................................................[4]

**(b)** In another dive from the same platform, the diver performs a somersault during the descent. He straightens, and again enters the water as shown in Fig. 2.1.

Discuss whether the speed of entry into the water is greater than, less than or equal to the speed calculated in **(a)(ii)**. Ignore any effects of air resistance.

..........................................................................................................................................

..........................................................................................................................................

..........................................................................................................................................

......................................................................................................................................[3]

[Total: 8]

MARKING SCHEME:

| | | |
|---|---|---|
| **(a)** | **(i)** (increase in g.p.e. = *mgh* **OR** $65 \times 10 \times 8$ =) 5200 J | B1 |
| | **(ii)** **EITHER** | |
| | k.e. gained = g.p.e. lost | C1 |
| | $\frac{1}{2} mv^2 = 5200$ in any form | C1 |
| | $v^2 = 5200 / (0.5 \times 65)$ **OR** 160 | C1 |
| | $v = 12.6$ m/s e.c.f. **(a)(i)** | A1 |
| | **OR** | |
| | $v^2 = u^2 + 2as$ / $v^2 = 2gh$ | (C1) |
| | $v^2 = 2 \times 10 \times 8$ | (C1) |
| | $v^2 = 160$ | (C1) |
| | $v = 12.6$ m/s e.c.f. **(a)(i)** | (A1) |
| **(b)** | speed is the same | B1 |
| | **EITHER** | |
| | loss in g.p.e. is the same | B1 |
| | k.e. gained is the same | B1 |
| | **OR** | |
| | acceleration is the same | (B1) |
| | distance fallen is the same | (B1) |

**[Total: 8]**