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Topic: Work, Energy and Power
MEMORANDUM Basic Multiple Choice Questions
(Level 1 and Level 2 Learners)

1. scalar; a straight line or just a number

2. vector; an arrow

3. vector; an arrow

4. A

5. A

6. B

7. A

8. scalar; just a number

9. A

10. A

11. A

12 (a) A

12 (b) A

13. B

14 (a) B

14 (b) B

15. B

16. A

17. B

18 (a) B

18 (b) A

19 (a) B

19 (b) B

20. B

21. B

22. B

23. C

24. A

25. D

26. B

27 (a). C

27 (b). C

28. B

29. A

30. D

31. A

32. C Do not show the weight, **w**, and a component of the weight at the same time.

33. B

34. C

35. D

36. D

37 (C)

$$E_p \text{ at top} = E_k \text{ at bottom} \\ = \frac{1}{2} m v^2 = \frac{1}{2} \times 2 \times 12^2 = 144 \text{ J}$$

38 (D) $W = F \Delta x$

$$39 (D) E_k = \frac{1}{2} m v^2 \\ \text{new } E_k' = \frac{1}{2} m (2v)^2 \\ = 4 (\frac{1}{2} m v^2) = 4 E_k$$

40 (B) Total energy remains constant.

41 (D) Total energy = $E_k + E_p$

42 (C) $W = F \Delta x = 40 \times 8 = 320 \text{ J}$

$$43 (C) W = E_p + E_k \\ = m g h + \frac{1}{2} m v^2$$

$$44 (C) F_{\text{net}} = m a = \text{kg} \cdot \text{m} \cdot \text{s}^{-2}$$

45 (B) watt = joule per second

$$46 (D) W = \Delta E_p = m g \Delta h \\ = (40)(9,8)(6) \\ = 2352 \text{ J}$$

47 (B) $E_p = m g h$
increases with height

48 (a) D

As it drops, it loses E_p as the distance it drops increases.

48 (b) A

As it drops, it falls faster and gains E_k as the distance it drops increases.

48 (c) B

Mechanical energy = $E_p + E_k$
= a constant

48 (d) B

Weight = $m g$

Both mass and **g** are constants.

49 (C)

$$\Delta E_p = m g \Delta h \\ \text{where } \Delta h \text{ is the vertical height gained} \\ \Delta h = 400 - 350 \\ = 50 \text{ m}$$

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MEMORANDUM Topic : Work, Energy and Power
Difficult Multiple Choice Questions
(Level 5 - 7 Learners)

2

- 1 (D) $F_{\text{net}} = m a$
 2 (D) Air friction decreases acceleration
 3 (D) volt = joule per coulomb
 4 (B) $K_{\text{at bottom}} = U_{\text{at top}}$
 5 (A) Mechanical energy ($U + K$) is conserved
 6 (B)
 7 (A) $\frac{1}{2} m v^2 = m g h$
 8 (C) $K = \frac{1}{2} (\frac{1}{2} m) (2 v)^2 = 2 \times \frac{1}{2} m v^2 = 2 E$
 9 (C) $\Delta U_{\text{lost}} = \Delta K_{\text{gained}}$
 So $\Delta U = \frac{1}{2} m v^2$ Thus $m = \frac{2 \Delta U}{v^2}$

10 (C)

11 (C) $\Delta U = m g \Delta h = (10)(2) = 20 \text{ J}$
 $\Delta K \text{ (due to net force) } = F_{\text{net}} \Delta x$
 $= (15 - 10) \times 2$
 $= (5)(2)$
 $= 10 \text{ J}$

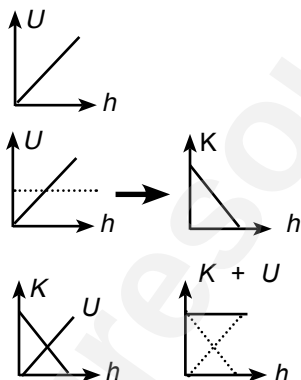
12 (C)

13 (D) $V \cdot C \cdot s^{-1} = \frac{J}{C} \cdot C \cdot s^{-1} = J \cdot s^{-1} \neq J$

14 (A) $U = m g h \propto h$

$U + K = \text{a constant}$
 As U increases,
 K decreases

RULE : fold U graph
 over a horizontal line
 midway up the U - axis
 to get K graph



The total of $U + K$ must remain constant.

15 D Only the work done against friction produces a heating effect. The net or resultant force ($F - f$) accelerates the object.

16. B $P = \frac{W}{\Delta t} = \frac{F s}{\Delta t} = \frac{(m g) h}{\Delta t}$

17. D Newton's Third Law

18. (B) $E_p = m g h = \text{kg} \cdot \text{m} \cdot \text{s}^{-2} \cdot \text{m} = \text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2}$

19. B

Horizontal component = $F \cdot \cos 60^\circ = F_{\text{applied}}$

$F_{\text{net}} = m \cdot a.$

$F_{\text{applied}} = m \cdot a + F_{\text{friction}}$

The applied force accelerates the object and compensates for friction.

$F_{\text{friction}} = F \cdot \cos 60^\circ - m \cdot a \text{ towards Q}$

20. A

A constant force produces a constant acceleration.

If v increases, so does $p = mv$ and $E_k = \frac{1}{2} mv^2$

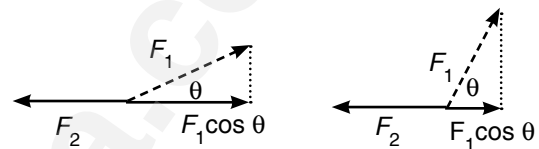
21. C $F_x < F_y$ as incline X is less steep and requires less force.

But $W = m \cdot g \cdot h$ is the same for both.

22. A A joule is a $\text{N} \cdot \text{m}$ not a $\text{N} \cdot \text{s}$.

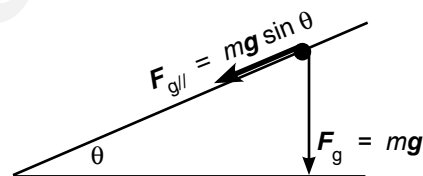
23. D As the angle increases, $\cos \theta$ gets less.

Thus the horizontal component $F_1 \cos \theta$ gets less.



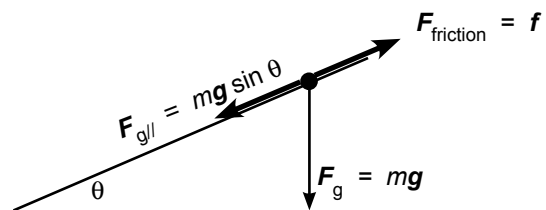
So the resultant force $F_2 - F_1 \cos \theta$ gets bigger.

24. C



If the object stands still then the

magnitude of the friction force = magnitude of $F_{g||}$



25. C Work done = **change** in energy
 $W = m g h + 0,5 m v^2$
 $= m g h + 0$
 as v does not change
 $P = \frac{W}{\Delta t} = \frac{m g h}{\Delta t} = m g v$

1.1 By measuring the effects of energy on visible matter.
 1.2 Potential energy is energy that lifts an object up and this same energy is called kinetic energy if it makes an object move faster.

1.3 formulae

1.4 A force must be applied and the object must move.

1.5 scalar 1.6 energy

1.7 positive 1.8 negative

1.9 The system moves faster or is lifted up higher

2.

2.1 The sum of the gravitational potential energy and the kinetic energy..

2.2 In an isolated system in the absence of air friction, the sum of the gravitational potential energy and the kinetic energy of a body remains constant.

2.3 Mechanical energy = $E_p + E_k$

2.4 Nothing enters or leaves the system.

2.5 The total energy of the system.

2.6 $E_p + E_k$

Only the gravitational force must be present.

2.7 The kinetic energy of the falling stone increases by 30 J.

2.8 increase in E_k

$$3.1 \quad E_k = \frac{1}{2} m v^2 = \frac{1}{2} (2) (4)^2 = 16 \text{ J}$$

3.2 16 J

3.3 (a)(i) $30 + 16 = 46 \text{ N}$ to the right
 (ii) 0°

(b)(i) $30 - 14 = 16 \text{ N}$ to the right
 (ii) 180°

(c) It acts in the opposite direction.

$$(d) \quad W_{\text{useful}} = \Delta E_k = \frac{1}{2} m (v_f^2 - v_i^2) = \frac{1}{2} (10) (5^2 - 0) = 125 \text{ J}$$

(e) Work done by a force is the product of the displacement and the component of the force acting in the direction of the displacement.

$$(f) \quad W = F \Delta x \cos \theta$$

4.

4.1 negative

4.2 negative

4.3 transferring energy out of

4.4 thermal energy

4.5 Thermal energy is due to the totally random motion of the molecules. Very little of this energy can be collected and used to do useful work. (Compare this to objects on a junk heap)

4.6 The energy caused by the random motion of molecules cannot be easily collected in order to do useful work.

4.7 Thermal energy is the random, disordered potential and kinetic energies of the randomly moving and jiggling molecules.

4.8 Heat is the transfer of disordered energy by molecules doing work randomly on a microscopic scale and raising the temperature.

4.9 Heating transfers energy from something at a higher temperature to something at a lower temperature.

4.10 Temperature is a measure of the random kinetic energy of the molecules.

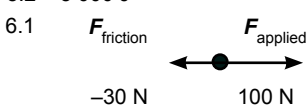
5.

$$5.1 \quad E_k = 5\,000 = \frac{1}{2} m v^2$$

$$v^2 = \frac{5\,000}{\frac{1}{2} (4)} = 2\,500$$

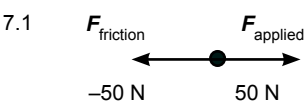
$$v = 50 \text{ m}\cdot\text{s}^{-1}$$

5.2 5 000 J



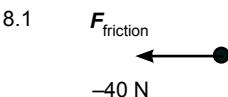
$$6.2 \quad F_{\text{net}} = 100 - 30 = 70 \text{ N to the right}$$

$$6.3 \quad W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = (70)(10) \cos 0^\circ = (70)(10)(1) = 700 \text{ J}$$



$$7.2 \quad F_{\text{net}} = 50 - 50 = 0 \text{ N}$$

$$7.3 \quad W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = (0)(8) \cos 0^\circ = (0)(8)(1) = 0 \text{ J}$$



$$8.2 \quad F_{\text{net}} = -40 \text{ N}$$

$$8.3 \quad W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = (40)(12) \cos 180^\circ = (40)(12)(-1) = -480 \text{ J}$$

9.1

$$9.2 \quad F_{\text{net}} = 0 \text{ N}$$

$$9.3 \quad W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = 0 \text{ J}$$

10.1 Slows down motion, causes a heating effect.

10.2 Gravitational force of the Earth.

10.3 two

10.4 contact

10.5 It must stay in contact with the object

11.

11.1 The work done on an object by a net force is equal to the change in the object's kinetic energy.

$$11.2 \quad W_{\text{net}} = \Delta E_k$$

$$F_{\text{net}} \Delta x = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$F_{\text{net}} (200) = \frac{1}{2} (100) (40^2 - 0)$$

$$F_{\text{net}} = \frac{80\,000}{200} = 400 \text{ N forwards}$$

$$11.3 \quad W_{\text{net}} = \Delta E_k$$

$$F_{\text{net}} \Delta x = \frac{1}{2} m (v_f^2 - v_i^2)$$

Only a negative force causes braking.

$$-8\,400 \Delta x = \frac{1}{2} (2\,600) (10^2 - 30^2)$$

$$-8\,400 \Delta x = 1\,300 (100 - 900)$$

$$\Delta x = \frac{-1\,300 \times 800}{-8\,400} = 123,81 \text{ m}$$

11.4

$$W_{\text{net}} = \Delta E_k$$

$$F_{\text{net}} \Delta x = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$F_{\text{net}} (50) = \frac{1}{2} (2\,400) (0 - 20^2)$$

$$F_{\text{net}} = \frac{-480\,000}{50} = -9\,600 \text{ N}$$

The net force acts against the direction of motion.

$$11.5 \quad F_{\text{net}} = 150 - 50 = 100 \text{ N}$$

$$W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = (100)(50) \cos 0^\circ = (100)(50)(1) = 5\,000 \text{ J}$$

$$W_{\text{net}} = \frac{1}{2} m (v_f^2 - v_i^2)$$

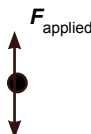
$$5\,000 = \frac{1}{2} (10) (v_f^2 - 0^2)$$

$$5\,000 = 5 v_f^2$$

$$v_f^2 = \frac{5\,000}{5} = 1\,000 \quad \therefore v_f = 31,62 \text{ m}\cdot\text{s}^{-1}$$

$$12.1 \quad E_p = m g h = (20)(9,8)(2) = 392 \text{ J}$$

12.2



Upward direction is positive.

$$F_{\text{gravity}} = F_g = m g = (100)(-9,8) = -980 \text{ N}$$

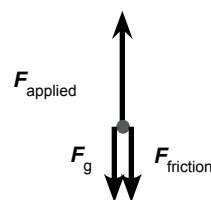
$$F_{\text{net}} = F_{\text{applied}} + F_g = 980 - 980 = 0 \text{ N}$$

$$W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = (0)(10) \cos 0^\circ = (0)(10)(1) = 0 \text{ J}$$

12.3 The gravitational field did negative work that transferred the same amount of energy out of the system.

13.

free-body diagram



$$F_g = m g = (51,02)(9,8) = 500 \text{ N}$$

$$F_{\text{net}} = F_{\text{applied}} + F_{\text{friction}} + F_{\text{gravity}} = 3\,000 - 600 - 500 = 1\,900 \text{ N upwards}$$

$$W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = (1\,900)(100) \cos 0^\circ = 190\,000 \text{ J}$$

$$W_{\text{net}} = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$190\,000 = \frac{1}{2} (51,02) (v_f^2 - 0)$$

$$v_f^2 = \frac{190\,000}{25,51} = 7448,06$$

$$\therefore v_f = 86,3 \text{ m}\cdot\text{s}^{-1}$$

14 $W = F_{\text{horizontal}} \Delta x \cos \theta$
 $= (80 \cos 30^\circ)(4)(\cos 0^\circ)$
 $= 277,13 \text{ J}$

15.
 15.1 0 J no change in speed or height
 15.2 0 J no change in speed or height
 15.3 Work is done as height increases.
 $W = \Delta E_p = m g \Delta h$
 $= (10)(9,8)(1,2) = 117,6 \text{ J}$
 15.4 Work is done because speed changes
 $F_{\text{net}} = m a = (10)(0,5) = 5 \text{ N}$
 $W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta$
 $= (5)(5) \cos 0^\circ$
 $= (25)(1) = 25 \text{ J}$

15.5 **Work** done is a transfer of **ordered energy**, on a **big** scale (macroscopic), by a moving directed force

Heat is a transfer of **disordered energy** by molecules doing work randomly on a **microscopic** scale, and raising the temperature.

15.6 **Heating** transfers energy from something at a higher temperature to something at a lower temperature.

16.
 16.1 $E_p = m g h$
 $= (40)(9,8)(3) = 1176 \text{ J}$

16.2 $E_k = \frac{1}{2} m v^2$
 $= \frac{1}{2} (40)(2)^2 = 80 \text{ J}$

16.3 Energy is used to compensate for air friction and friction with the slide surface. Some energy appears as noise energy and thermal kinetic energy due to friction. Some energy is also used to raise the internal energy of the surroundings.

17.
 Take up as + 
 $F_g = m g$
 $= (4)(-9,8) = -39,2 \text{ N}$

$W_{\text{net}} = \Delta E_k$
 $F_g \Delta x \cos \theta = E_{\text{kf}} - E_{\text{ki}}$
 $39,2 \Delta x \cos 180^\circ = 0 - 5000$
 $\Delta x = \frac{-5000}{-39,2}$
 $= 127,55 \text{ m}$

18.1 $E_p = m g h = (60)(9,8)(80)$
 $= 47040 \text{ J}$

18.2
 $\Sigma ME_i = \Sigma ME_f$
 $m g h_i + \frac{1}{2} m v_i^2 = m g h_f + \frac{1}{2} m v_f^2$
 $(60)(9,8)(80) + \frac{1}{2} (60)(0^2) =$
 $(60)(9,8)(0) + \frac{1}{2} (60) v_f^2$
 $47040 + 0 = 0 + 30 v_f^2$
 $v_f^2 = \frac{47040}{30} = 1568$
 $v_f = 39,6 \text{ m}\cdot\text{s}^{-1}$

18.3 $E_p + E_k = \text{a constant} = 47040 \text{ J}$
 18.4 47040 J
 18.5 $E_{\text{p at 35 m}} = m g h = (60)(9,8)(35)$
 $= 20580 \text{ J}$

$E_p + E_k = 47040$
 $E_k = 47040 - 20580 = 26460 \text{ J}$
 $26460 = \frac{1}{2} (60) v^2$
 $v^2 = \frac{26460}{30} = 882$
 $v = \sqrt{882} = 29,7 \text{ m}\cdot\text{s}^{-1}$

18.6 $W = F \Delta x \cos \theta = F \Delta x \cos 180^\circ$
 Friction force acts against the motion.

47040 = $F_{\text{friction}} (0,96)(-1)$
 $F_{\text{friction}} = \frac{-47040}{0,96} = -49000 \text{ N}$

Friction force is negative as it opposes the motion.

19
 19.1 it conserves mechanical energy *ME* when there is no air friction by **interchanging** the potential energy and the kinetic energy. No outside forces are needed.

The increase in E_k is provided for by the decrease in E_p .

19.2 Friction or some external force is present.

19.3 Gravitational force 19.4 Yes.

19.5 A force is regarded as a **conservative force** if the net work done by the force is zero as it moves an object around on a **closed path, starting and ending at the same point**.

19.6 $W_{\text{nc}} = \Delta E_p + \Delta E_k$

19.7 An applied force, friction force.

19.8 The work done by a non-conservative force is equal to the change in the total mechanical energy of the system.

20.
 20.1 $W = F \Delta x \cos \theta = F \Delta x \cos 0^\circ$
 $= (200)(5)(1) = 1000 \text{ J}$

20.2 E_k and gravitational E_p

20.3 $\Delta E_p = m g \Delta h$
 $= (15)(9,8)(5) = 735 \text{ J}$

20.4 work done = energy transferred
 $W_{\text{nc}} = \Delta E_p + \Delta E_k$
 $\Delta E_k = W - \Delta E_p$
 $= 1000 - 735 = 265 \text{ J}$

21.
 21.1 Energy can neither be created nor destroyed, but by doing work it can be transferred from one system to another.

21.2 At 5 m:
 $E_p = m g h = (0,1)(9,8)(5) = 4,9 \text{ J}$
 $E_k = \frac{1}{2} m v^2 = \frac{1}{2} (0,1)(4)^2 = 0,8 \text{ J}$

$E_{\text{total}} = E_p + E_k = 5 + 0,8 = 5,7 \text{ J}$

At ground level all the energy = E_k

$E_k + E_p = 5,7 = \frac{1}{2} m v^2 + 0$
 $v^2 = \frac{5,7}{0,05} = 114$
 $v = 10,68 \text{ m}\cdot\text{s}^{-1}$

21.3 $v_f = v_i + a \Delta t$
 $0 = 10,68 + a(0,2)$
 $a = \frac{-10,68}{0,2} = -53,4 \text{ m}\cdot\text{s}^{-2}$

$F = m a$
 $= (0,1)(-53,4) = -5,34$
 Thus a force of 5,34 N acts upwards.

21.4 As the ball pushes through the air there is a heating effect due to friction. Part of the initial potential energy appears as internal energy of the ball and the air in order to do work to overcome air friction. Thus the final kinetic energy is less than the initial potential energy and the speed is correspondingly decreased.

22.
 22.1 Take up as positive.


 $F_{\text{grav}} = m g = (12)(-9,8) = -117,6 \text{ N}$

$F_{\text{net}} = m a$
 $180 - 117,6 = 12 a$
 $a = \frac{62,4}{12} = 5,2 \text{ m}\cdot\text{s}^{-2} \text{ upwards}$

22.2 $W = F \Delta x \cos \theta$
 $= F \Delta x \cos 0^\circ$
 $= (180)(7,5)(1) = 1350 \text{ J}$

22.3 Gravitational potential energy and kinetic energy and internal energy.

22.4 $\Delta E_p = m g \Delta h$
 $= (12)(9,8)(7,5) = 882 \text{ J}$

22.5 Total work done by applied force
 $W_{\text{nc}} = \Delta E_p + \Delta E_k$
 $\Delta E_k = W_{\text{nc}} - \Delta E_p$
 $= 1350 - 882$
 $= 468 \text{ J}$

Power

33.1 Power is the rate of doing work.
 or, the rate at which energy is expended.
 33.2 A watt is the rate of working or
 energy transfer of one joule per second.

$$33.3 \quad P = \frac{W}{\Delta t} = \frac{20}{4} = 5 \text{ W}$$

33.4
 Magnitude of friction = magnitude of applied force

$$P = F \bar{v}$$

$$80\,000 = F \cdot 40$$

$$F = \frac{80\,000}{40} = 2\,000 \text{ N}$$

24.
 work done by motor : $W = P \Delta t$
 $= (200)(40) = 8\,000 \text{ J}$

work done lifting the mass :
 $W = \Delta E_p = m g \Delta h = (30)(9,8)(7) = 2\,058 \text{ J}$

efficiency = $\frac{\text{work done lifting the mass} \times 100}{\text{work done by motor}}$

$$= \frac{2\,058}{8\,000} \times 100$$

$$= 25,73 \%$$

25.
 25.1 Without air resistance
 $v_f = v_i + a \Delta t = 0 + (9,8)(5) = 49 \text{ m} \cdot \text{s}^{-1}$

$$E_k = \frac{1}{2} m v^2 = \frac{1}{2} (20)(49)^2 = 24\,010 \text{ J}$$

With air resistance
 $v_f = 40 \text{ m} \cdot \text{s}^{-1}$
 $E_k = \frac{1}{2} m v^2 = \frac{1}{2} (20)(40)^2 = 16\,000 \text{ J}$

Energy used to overcome air friction
 $W = \Delta E_k = 24\,010 - 16\,000 = 8\,010 \text{ J}$
 Some mechanical energy is transferred to the air as thermal energy by working against air friction.
 The surrounding air molecules thus jitter (move randomly) around more energetically.

25.2
 $W = \Delta E_k = E_{kf} - E_{ki}$
 $= 0 - 16\,000 = -16\,000 \text{ J}$
 $W = F \Delta x \cos \theta$
 $= F \Delta x \cos 180^\circ$
 $-16\,000 = F (0,4)(-1)$
 $F = \frac{-16\,000}{-0,4} = 40\,000 \text{ N upwards}$

26.
 $40 \text{ km} \cdot \text{h}^{-1} = \frac{40}{3,6} = 11,1 \text{ m} \cdot \text{s}^{-1}$

$$P = F v$$

$$50\,000 = F \cdot 11,1$$

$$F = \frac{50\,000}{11,1} = 4\,500 \text{ N}$$

$$W = F \Delta x \cos \theta = F \Delta x \cos 0^\circ$$

$$= (4500)(10 \times 10^3)(1) \text{ distance in m}$$

$$= 4,5 \times 10^4 \text{ kJ}$$

27.
 $P = \frac{W}{\Delta t} = \frac{\Delta E_p}{\Delta t} = \frac{m g \Delta h}{\Delta t}$
 $= \frac{(3)(9,8)(10)}{1} = 294 \text{ W}$

28.
 1 litre = 1 dm³
 Officially the mass of 1 dm³ of water at its densest (at 4°C) = 1 kg

The mass of 140 litres of water at 4°C = 140 kg
 The speed of the water is constant, v_i

$$W_{nc} = \Delta E_p + \Delta E_k$$

$$= m g (h_f - h_i) + \frac{1}{2} m (v_f^2 - v_i^2)$$

$$= (140)(9,8)(40 - 0) + \frac{1}{2} (140)(v_i^2 - v_i^2)$$

$$= 54\,880 + (70)(0)$$

$$= 54\,880 \text{ J}$$

$$\text{Power } P = \frac{W}{\Delta t} = \frac{54\,880 \text{ J}}{60 \times 2 \text{ s}} = 457,33 \text{ W}$$

Our input has to be more than 457,33 W to allow for power losses due to friction effects that must be compensated for.

$$\text{Efficiency} = 60\% = \frac{60}{100} = 0,6$$

The minimum power to raise the water is 457,33 W in a frictionless system but more power must be added to compensate for the friction of the water as it slides along the walls of the pipes.

The minimum power required to pump water in this pipe is = $\frac{457,33}{0,6} = 762,22 \text{ W}$

29.
 29.1 Both do the same amount of work because $W = \Delta E_p = m g \Delta h$ is the same for both of them.
 120 kg mass is raised vertically 2 m.

29.2 P. The less time the work takes, the greater the power.

30.
 30.1 No work is done while the mass is stationary.

$$W = \Delta E_p = m g \Delta h$$

$$= (15)(10)(1,2) = 180 \text{ J}$$

$$30.2 \quad P = \frac{W}{\Delta t} = \frac{180}{2} = 90 \text{ W}$$

31.
 $\frac{360 \text{ km}}{1 \text{ h}} = \frac{360\,000 \text{ m}}{(60)(60) \text{ s}}$

$$= \frac{360}{3,6} = 100 \text{ m} \cdot \text{s}^{-1}$$

$$P = F \bar{v}$$

$$P = (4\,680)(100) = 468 \text{ kW}$$

32.
 32.1 Energy input needed by motor
 $W = P \Delta t = (100)(50) = 5\,000 \text{ J}$
 work done by motor = energy output
 $= \Delta E_p = m g \Delta h$
 $m g \Delta h = (60)(10)(5) = 3\,000 \text{ J}$
 Efficiency = $\frac{\text{output}}{\text{input}} \times 100 = \frac{3000}{5000} \times 100$

$$= 60 \%$$

32.2 Energy input needed by motor
 $W = P \Delta t = (80)(40) = 3\,200 \text{ J}$
 Efficiency = $\frac{\text{output}}{\text{input}} \times 100$

$$60 = \frac{\text{output} \times 100}{3\,200}$$

$$\text{output} = (60)(32) = 1\,920 \text{ J} = \Delta E_p$$

$$1\,920 = m g \Delta h = (20)(9,8) \Delta h$$

$$\Delta h = \frac{1\,920}{196} = 9,8 \text{ m change in height}$$

32.3 Output by motor
 $W = \Delta E_p = m g \Delta h$
 $= (2)(10)(4) = 80 \text{ J}$
 Efficiency = $\frac{\text{output}}{\text{input}} \times 100$

$$40 = \frac{(80)(100)}{\text{input}}$$

$$\text{input} = \frac{8\,000}{40} = 200 \text{ J} = W$$

$$W = P \Delta t$$

$$200 = 50 \Delta t$$

$$\Delta t = \frac{200}{50} = 4 \text{ s}$$

1.
 1.1 (i) $E_k = \frac{1}{2} m v^2$
 (ii) $E_p = m g h$
 1.2 Transferred.
 1.3 $W = \Delta E_p = m g \Delta h$
 $= (20)(9,8)(8)$
 $= 1568 \text{ J}$
 1.4 0. It has no resistance to move against
 The gravity field does the work.
 1.5 $W = \Delta E_k = \frac{1}{2} m (0 - v_i^2)$
 $= -\frac{1}{2} (30)(6)^2$
 $= -540 \text{ J}$
 Friction does negative work.

22.6 $W = \Delta E_k$
 $= \frac{1}{2} m (v_f^2 - v_i^2)$
 $-150 = \frac{1}{2} (6)(0 - v^2)$
 $v^2 = \frac{-150}{-3} = 50$
 $v = \sqrt{50} = 7,07 \text{ m}\cdot\text{s}^{-1}$

2.
 2.1 potential energy
 2.2 kinetic energy
 2.3
 • the object must move
 • the movement must be against some resistance
 • the force must not be at 90° to the movement
 • a contact force must remain in contact with the object
 2.4 (i)

$$W = F_{\text{net}} \Delta x \cos \theta$$

$$= (50)(5) \cos 0^\circ$$

$$= (250)(1) = 250 \text{ J}$$

- (ii) 250 J
 (energy transferred = work done)

2.5
 0 There was no movement.
 $W = F_{\text{net}} \Delta x \cos \theta$ and $\Delta x = 0$.

2.6
 $W = F_{\text{horizontal}} \Delta x \cos \theta$
 $= (80 \cos 30^\circ)(4)(\cos 0^\circ)$
 $= 277,13 \text{ J}$

3.
 3.1 decreases
 3.2

$$\Sigma ME_i = \Sigma ME_f$$

$$m g h_i + \frac{1}{2} m v_i^2 = m g h_f + \frac{1}{2} m v_f^2$$

$$(50)(9,8)(2420) + \frac{1}{2} (50)(0^2) =$$

$$(50)(9,8)(0) + \frac{1}{2} m v_f^2$$

$$1,1858 \times 10^6 + 0 = 0 + \frac{1}{2} m v_f^2$$

$$\frac{1}{2} m v_f^2 = 1,1858 \times 10^6 \text{ J}$$

24.3 $v_f = v_i + a \Delta t$
 $= 0 + (9,8)(10) = 98 \text{ m}\cdot\text{s}^{-1}$

$$E_{k \text{ after } 10s} = \frac{1}{2} m v^2 = \frac{1}{2} (50)(98)^2$$

$$= 240100 \text{ J} = 2,401 \times 10^5 \text{ J}$$

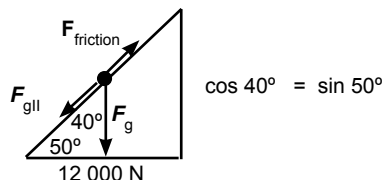
$$E_p + E_k = 1,1858 \times 10^6$$

$$E_p = 1,1858 \times 10^6 - 2,401 \times 10^5$$

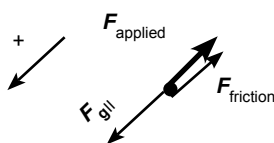
$$= 945700 \text{ J} = 9,457 \times 10^5 \text{ J}$$

3.4 $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
 $2420 = 0 + \frac{1}{2} (9,8) \Delta t^2$
 $\Delta t^2 = \frac{2420}{4,9} = 493,88$
 $\Delta t = 22,2 \text{ s}$

4.1
 weight = $m g = (1224,5)(9,8) = 12000 \text{ N}$



The component of the car's weight that pulls it down the slope
 $F_{g \parallel} = m g \sin 50^\circ (= m g \cos 40^\circ)$
 $= (12000) \sin 50^\circ = 9192,5 \text{ N}$



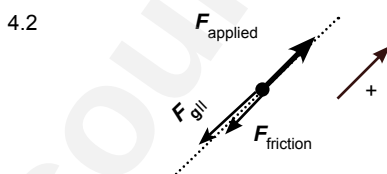
Take down the slope as positive (since the car is moving in that direction)

$$F_{\text{net}} = 0 = F_{\text{applied}} + F_{g \parallel} + F_{\text{friction}}$$

$$= F_{\text{applied}} + 9192,5 - 2314$$

$$F_{\text{applied}} = -6878,5 \text{ N}$$

$$= 6878,5 \text{ up the slope}$$



4.2
 When the car moves up the slope at a constant speed then friction acts down the slope.

Take up the slope as positive
 $F_{\text{net}} = 0 = F_{\text{applied}} + F_{g \parallel} + F_{\text{friction}}$
 $= F_{\text{applied}} - 9192,5 - 2314$
 $F_{\text{applied}} = 11506,5 \text{ N up the slope}$

5.
 Take up as +
 $F_g = m g$
 $= (4000)(-9,8)$
 $= -39200 \text{ N}$

$$W_{\text{net}} = \Delta E_k$$

$$F_g \Delta x \cos \theta = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$(39200)(1000) \cos 180^\circ = \frac{4000}{2} (v_f^2 - 1500^2)$$

$$-3,92 \times 10^7 = 2000 v_f^2 - 4,5 \times 10^9$$

$$v_f^2 = \frac{4,5 \times 10^9 - 3,92 \times 10^7}{2000} = 2230400$$

$$v = 1493,45 \text{ m}\cdot\text{s}^{-1}$$

6.
 Let to the right be + and upwards be positive.
 Assume the bullet and pendulum begin to move with a combined horizontal speed of v_i .
 $W_{\text{nc}} = \Delta E_p + \Delta E_k$
 $m = 1,98 + 0,02 = 2 \text{ kg}$
 Mass of bullet and pendulum.

$$0 = m g (h_f - h_i) + \frac{1}{2} m (v_f^2 - v_i^2)$$

$$0 = (2)(9,8)(8 - 0) + \frac{1}{2} (2)(0 - v_i^2)$$

$$0 = 100 - v_i^2$$

$$\therefore v_i^2 = 156,8$$

$$\therefore v_i = 12,52 \text{ m}\cdot\text{s}^{-1}$$

7.1
 $\Sigma ME_i = \Sigma ME_f$
 $m g h_i + \frac{1}{2} m v_i^2 = m g h_f + \frac{1}{2} m v_f^2$
 $(1)(9,8)(0) + \frac{1}{2} (1)(6,4)^2 = (1)(9,8) h_f + \frac{1}{2} (1)(0^2)$
 $0 + 20,48 = 9,8 h_f + 0$
 $h_f = \frac{20,48}{9,8} = 2,09 \text{ m}$

7.2
 $W_{\text{nc}} = \Delta E_p + \Delta E_k$
 $0 = m g (h_f - h_i) + \frac{1}{2} m (v_f^2 - v_i^2)$
 $0 = (2)(9,8)(3,5 - 0) + \frac{1}{2} (2)(v_f^2 - 0)$
 $0 = 68,6 - v_i^2$
 $\therefore v_i^2 = 68,6$
 $\therefore v_i = 8,28 \text{ m}\cdot\text{s}^{-1}$

8.
 8.1
 $\Sigma ME_i = \Sigma ME_f$
 $m g h_i + \frac{1}{2} m v_i^2 = m g h_f + \frac{1}{2} m v_f^2$
 $(20)(9,8)(125) + \frac{1}{2} (20)(0^2) =$
 $(20)(9,8)(0) + \frac{1}{2} m v_f^2$
 $24500 + 0 = 0 + \frac{1}{2} m v_f^2$
 $\frac{1}{2} m v_f^2 = 24500 \text{ J}$
 with air resistance : $v = 40 \text{ m}\cdot\text{s}^{-1}$
 $E_k = \frac{1}{2} m v^2 = \frac{1}{2} (20)(40)^2$
 $= 16000 \text{ J}$

Energy used to overcome air friction
 $W = \Delta E_k = 24500 - 16000 = 8500 \text{ J}$
 8.2 $W = F \Delta x \cos \theta = F \Delta x \cos 180^\circ$
 Friction transfers energy out of the system so it does negative work.
 $-16000 = 50000 \Delta x (-1)$
 $\Delta x = \frac{16000}{50000} = 0,32 \text{ m}$

9.
 $W = \text{change in energy of moving bullet}$
 $= \Delta E_k + \Delta E_p$
 $= \frac{1}{2} m (v_f^2 - v_i^2) + 0$
 $= \frac{1}{2} (5 \times 10^{-3}) [0 - (10^3)^2]$
 $= -2500 \text{ J}$
 Work done by the tree is negative as it slows the bullet down.

10.

$$10.1 \quad v_f^2 = v_i^2 + 2 a \Delta x$$

$$4^2 = 0 + 2 a (0,04)$$

$$a = \frac{16}{0,08} = 200 \text{ m}\cdot\text{s}^{-2}$$

$$10.2 \quad F = m a$$

$$= (3 \times 10^{-3}) (200) = 0,6 \text{ N}$$

$$10.3 \quad W = F \Delta x \cos \theta$$

$$= F \Delta x \cos 0^\circ$$

$$= (0,6)(0,04)(1) = 0,024 \text{ J}$$

11.

$$F_g = m g = (2)(9,8) = 19,6 \text{ N}$$

$$F_{\text{net}} = F_{\text{friction}} + F_{\text{gravity}}$$

$$W_{\text{net}} = W_{\text{friction}} + W_{\text{gravity}}$$

$$= F_{\text{friction}} \Delta x \cos \theta + F_{\text{gravity}} \Delta x \cos \theta$$

$$= (5)(4)(\cos 180^\circ) + (19,6)(3)(\cos 0^\circ)$$

$$= -20 + 58,8$$

$$= 38,8 \text{ J}$$

$$W_{\text{net}} = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$38,8 = \frac{1}{2} (2) (v_f^2 - 6^2)$$

$$v_f^2 = 38,8 + 36 = 74,8$$

$$\therefore v_f = 8,65 \text{ m}\cdot\text{s}^{-1}$$

12.

12.1 Friction is present, thus it is not an isolated system.

$$12.2 \quad W_{\text{friction}} = F_{\text{friction}} \Delta x \cos \theta$$

$$= (2,5)(6)(\cos 180^\circ)$$

$$= (2,5)(6)(-1) = -15 \text{ J}$$

$$12.3 \quad +15 \text{ J}$$

12.4 Useful work changes speed or height

$$W_{\text{nc}} = \Delta E_p + \Delta E_k$$

$$= (m g h_f - m g h_i) +$$

$$\left(\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \right)$$

$$= (4)(9,8)(3) - 0 +$$

$$\frac{1}{2} (4) (2)^2 - \frac{1}{2} (4) (5)^2$$

$$= 117,6 + 8 - 50 = 75,6 \text{ J}$$

12.5 The car must do the real work required to change its height and speed as well as compensating for friction.

$$W_{\text{total}} = 75,6 + 15 = 90,6 \text{ J}$$

13.



$$\Delta E_k = 0 \quad W_{\text{friction}} = -4 \times 10^6 \text{ J}$$

$$\Delta E_p = m g h = (2000)(9,8)(70)$$

$$= 1372000 \text{ J}$$

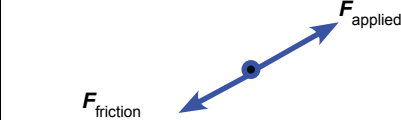
$$W_{\text{nc}} = W_{\text{applied}} + W_{\text{friction}} = \Delta E_p + \Delta E_k$$

$$W_{\text{applied}} - 4 \times 10^6 = 1372000 + 0$$

$$W_{\text{applied}} = 4000000 + 1372000$$

$$= 5372000 \text{ J}$$

14.



External forces F_{friction} and F_{applied} are **non-conservative** forces.

14.1 Work done by non-conservative forces

$$W_{\text{nc}} = \Delta E_p + \Delta E_k$$

$$= (m g h_f - m g h_i) + \left(\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \right)$$

$$= (4)(9,8)(3) - 0 + \frac{1}{2} (4) (5)^2$$

$$= 117,6 + 50 - 128$$

$$= 39,6 \text{ J}$$

14.2 Work done by the applied force:

$$W_{\text{friction}} = F \Delta x \cos \theta = (7)(6) \cos 180^\circ$$

$$= -42 \text{ J}$$

$$W_{\text{nc}} = 39,6$$

$$W_{\text{applied}} + W_{\text{friction}} = 39,6$$

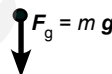
$$W_{\text{applied}} - 42 = 39,6 \text{ J}$$

$$\therefore W_{\text{applied}} = 81,6 \text{ J}$$

14.3 In the absence of non-conservative forces.

15.

free body diagram



$$W_{\text{net}} = \Delta E_k$$

$$F_g \Delta x \cos \theta = \frac{1}{2} m (v_f^2 - v_i^2)$$

$$m g \Delta x (\cos 180^\circ) = \frac{1}{2} (0,1) (v_f^2 - 6^2)$$

$$(0,1)(9,8) 1 - 0 (-1) = \frac{1}{2} (0,1) (v_f^2 - 36)$$

mass cancels

$$-9,8 + 18 = \frac{1}{2} v_f^2$$

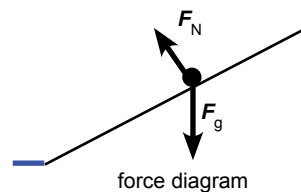
$$v_f^2 = 2(8,2) = 16,4$$

$$v_f = 4,05 \text{ m}\cdot\text{s}^{-1}$$

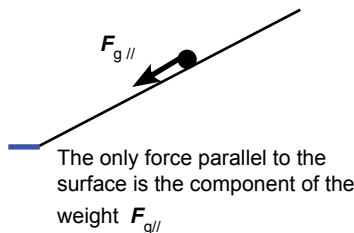
The object moves along the surface so only consider the forces that are parallel to the surface.

First, determine the component of the weight (F_g) that is parallel to the slope ($F_{g//}$)

16.1

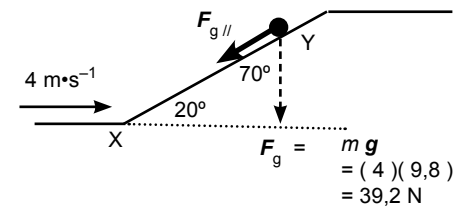


16.2



16.3

Take up the slope as positive



$$\text{NB.} \quad \cos 70^\circ = \sin 20^\circ$$

$F_{g//}$ is component of the weight parallel to the slope.

$$F_{g//} = m g \sin 20^\circ \quad (= m g \cos 70^\circ)$$

$$= 39,2 \sin 20^\circ$$

$$= 13,4 \text{ N}$$

$$F_{\text{net}} = F_{g//}$$

$$W_{\text{net}} = \Delta E_k$$

$$F_{g//} \Delta x \cos \theta = \left(\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 \right)$$

$$(13,4) \Delta x \cos 180^\circ = \frac{1}{2} (4) (0)^2 - \frac{1}{2} (4) (4)^2$$

At the topmost point it stops. $v_f = 0$.

$F_{g//}$ acts down the slope..

$$-13,4 \Delta x = -32$$

$$\Delta x = 2,39 \text{ m}$$

But $\Delta x = \text{distance XY} = 2,39 \text{ m}$

17.

For the dip :

$$E_k = \frac{1}{2} m v^2$$

$$E_k \text{ at bottom} = \frac{1}{2} m (3)^2 = 4,5 \text{ m}$$

$$E_k \text{ on top} = \frac{1}{2} m (2)^2 = 2 \text{ m}$$

$$\Delta E_k = 4,5 \text{ m} - 2 \text{ m} = 2,5 \text{ m}$$

The ΔE_k gained going down the dip is lost as it climbs out of the dip.

Out of the dip its speed is $2 \text{ m}\cdot\text{s}^{-1}$ again

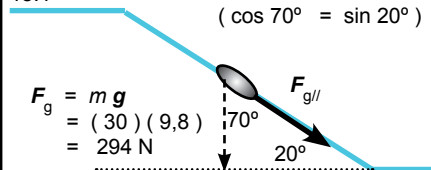
For the bump :

energy to get on top = $\Delta E_k = 2,5 \text{ m}$

energy available = $\frac{1}{2} m (2)^2 = 2 \text{ m}$

it will not get on top

18.1



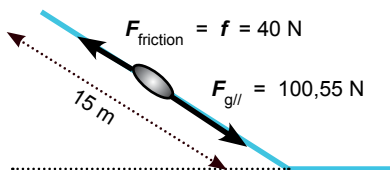
$$F_{g//} = m g \sin \theta \quad (= m g \cos 70^\circ)$$

$$= (294) (\sin 20^\circ)$$

$$= 100,55 \text{ N}$$

18.2

Diagram of forces parallel to the surface of the inclined plane.



Take down the plane, the direction of motion, as positive.

$$F_{\text{net}} = F_{g||} + f$$

$$= 100,55 - 40 = 60,55 \text{ N}$$

the friction opposes the motion.

$$W_{\text{net}} = \Delta E_k$$

$$F_{\text{net}} \Delta x \cos \theta = E_{kf} - E_{ki}$$

$$(60,55)(15)(\cos 0^\circ) = E_{kf} - \frac{1}{2}(30)(3)^2$$

$$908,25 = E_{kf} - 135$$

$$E_{kf} = 908,25 + 135$$

$$= 1043,25 \text{ J}$$

19.

19.1 kinetic energy

19.2 momentum

20.1

$$P = F \bar{v}$$

$$127\,000 = F(36)$$

$$F = \frac{127\,000 \text{ N}}{36} = 3\,527,8 \text{ N}$$

$$20.2 \quad P = F \bar{v}$$

$$92\,000 = F(36)$$

$$F = \frac{92\,000 \text{ N}}{36} = 2\,555,6 \text{ N}$$

Force reduces by

$$3\,527,8 - 2\,555,6 = 972,2 \text{ N}$$

$$20.3 \quad P = F \bar{v}$$

The bigger the power, the bigger the force.

$$F = ma$$

The bigger the force the bigger the acceleration.

A car has better acceleration when the car is making more power in a lower gear.

$$20.4 \quad P = F \bar{v} = ma \bar{v}$$

The bigger the power, the bigger the force. the bigger the acceleration.

A car has better acceleration when the car is making more power in a lower gear.

20.5 harder

20.6

When a car goes forward, the back tyre is turned clockwise and pushes backwards against the road. By Newton's Third Law, the road friction pushes forwards against the tyre to slow it down so that the patch of tyre at A in contact with the road does not move horizontally. The tyre is stationary at point A for a brief moment as it changes its direction from moving down to moving up as it rotates (similar to a stone being stationary at the top of its path if it is thrown upwards).

The energy of motion comes from the internal energy (fuel + O₂) which, thanks to the car's mechanisms, appears as kinetic energy of the turning tyre.

The road exerts a continuous force on different portions of the rotating tyre which accelerates the car.

$$F_{\text{net}} \Delta t = m(v_f - v_i) \text{ acts for an instant on point A.}$$

A net force exerted for a given time **imposes an impulse** on the tyre leading to a **change in momentum**.

21.

21.1 Energy input needed by motor

$$W = P \Delta t = (20)(10) = 200 \text{ J}$$

output work done by motor

$$W = \Delta E_k = \frac{1}{2} m(v_f^2 - v_i^2)$$

$$= \frac{1}{2}(10)[5^2 - 0] = 125 \text{ J}$$

$$\text{Efficiency} = \frac{\text{output}}{\text{input}} \times 100 = \frac{125}{200}(100)$$

$$= 62,5 \%$$

21.2 Energy input needed by motor :

$$W = P \Delta t = (60)(8) = 480 \text{ J}$$

$$\text{Efficiency} = \frac{\text{energy output}}{\text{energy input}} \times 100$$

$$70 = \frac{\text{output} \times 100}{480}$$

$$\text{output} = (70)(4,8) = 336 \text{ J} = \Delta E_k$$

$$W = \Delta E_k = \frac{1}{2} m(v_f^2 - v_i^2)$$

$$336 = \frac{1}{2} m(v_f^2 - 0) = \frac{1}{2}(20)(v_f^2)$$

$$v_f^2 = \frac{336}{10} = 33,6$$

$$v_f = 5,8 \text{ m}\cdot\text{s}^{-1}$$

22.



$$22.1 \quad \Delta E_k = 0 \quad W_{\text{friction}} = -5,84 \times 10^6 \text{ J}$$

$$\Delta E_p = mgh = (1750)(9,8)(55)$$

$$= 943\,250 \text{ J}$$

$$W_{\text{nc}} = W_{\text{applied}} + W_{\text{friction}} = \Delta E_p + \Delta E_k$$

$$W_{\text{applied}} - 5,84 \times 10^6 = 943\,250 + 0$$

$$W_{\text{applied}} = 5,84 \times 10^6 + 943\,250 = 6,78 \times 10^6 \text{ J}$$

$$72 \text{ km}\cdot\text{h}^{-1} = \frac{72}{3,6} = 20 \text{ m}\cdot\text{s}^{-1}$$

$$v = \frac{\Delta x}{\Delta t} \text{ So } \Delta t = \frac{\Delta x}{v} = \frac{570}{20} = 28,5 \text{ s}$$

$$P = \frac{W}{\Delta t} = \frac{6,78 \times 10^6}{28,5} = 2,38 \times 10^5 \text{ W}$$

22.2 Zero. A net force causes acceleration, not a constant speed.

$$22.3 \quad 90 \text{ km}\cdot\text{h}^{-1} = \frac{90}{3,6} = 25 \text{ m}\cdot\text{s}^{-1}$$

$$\Delta E_p = mg(h_i - h_f)$$

$$= (1100)(9,8)(0 - 55) = -592\,900 \text{ J}$$

Truck's E_p is reduced as it moves downhill.

Thus loss of $E_p = -592\,900 \text{ J}$

F_{gravity} does this work, not the applied force.

$$\Delta E_k = \frac{1}{2} m(v_f^2 - v_i^2)$$

$$= \frac{1}{2}(1100)(25^2 - 20^2)$$

$$= +123\,750 \text{ J}$$

$$W_{\text{friction}} = F_{\text{friction}} \Delta x \cos \theta$$

$$= (6,44 \times 10^3)(570)(\cos 180^\circ)$$

$$= -3\,670\,800 \text{ J}$$

$$W_{\text{applied}} + W_{\text{friction}} = \Delta E_p + \Delta E_k$$

$$W_{\text{applied}} - 3\,670\,800 = -592\,900 + 123\,750$$

$$W_{\text{applied}} = -592\,900 + 123\,750 + 3\,670\,800$$

$$= 3\,201\,650 \text{ J} = 3,20 \times 10^6 \text{ J}$$

23.

$$P = F \bar{v}$$

$$261\,000 = 5\,560 \bar{v}$$

$$\bar{v} = \frac{261\,000 \text{ N}}{5\,560} = 46,94 \text{ m}\cdot\text{s}^{-1}$$

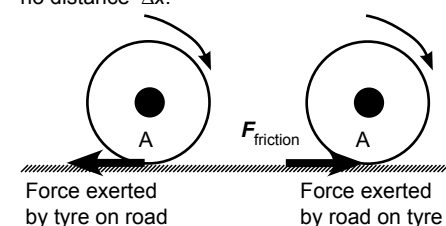
24.

24.1

When a car goes forward, the back tyre is turned clockwise and the bottom of the tyre exerts a backwards force against the road. By Newton's Third Law, road friction pushes forwards against the tyre to slow it down so that **the patch of tyre at A in contact with the road does not move**.

24.2

There is no displacement Δx of point A in the forward direction otherwise the tyre would skid or slip and not rotate. Thus the friction force acts for a brief time Δt but over no distance Δx .



A point on the tyre moves downwards as it approaches A and then upwards after leaving A. The tyre has no horizontal motion at A.

25.

25.1 kinetic energy

25.2 momentum and thus velocity

25.3 kinetic energy (any change in

velocity v changes E_k a lot as this

involves v^2 but changes the momentum far less as this only involves v)

25.4 $F_{\text{net}} \Delta x$ is a **scalar**

(vector • vector = scalar) and causes

a **change in kinetic energy**.

$F_{\text{net}} \Delta t$ is a **vector**

(vector • scalar = vector) and

causes a **change in momentum**.

25.5 bigger

25.6 smaller

1.1 B Work done is equal to the **change** in kinetic energy

1,2.1 $200 \times 1\,000 = 2 \times 10^5 \text{ kg}$

1.2.2 $E_{ki} + E_{pi} = E_{kf} + E_{pf}$ or $E_{mech\,i} = E_{mech\,f}$

$\frac{1}{2}mv_i^2 + mgh_i = E_{kf} + mgh_f$

$\frac{1}{2}m(0)^2 + (2 \times 10^5)(9,8)(150) = E_{kf} + (2 \times 10^5)(9,8)(0)$

$0 + (2 \times 10^5)(9,8)(150) = E_{kf} + 0$

$E_{kf} = 2,94 \times 10^8 \text{ J}$

1.2.3 $E_{kf} = \frac{1}{2}mv_f^2$

$2,94 \times 10^8 = \frac{1}{2}(2 \times 10^5)v_f^2$

$v_f = 54,22 \text{ m}\cdot\text{s}^{-1}$

1.2.4 $P = \frac{85}{100} \times \frac{W}{\Delta t} = \frac{(0,85)(2,94 \times 10^8)}{1}$
 $= 2,499 \times 10^8 \text{ W (Accept } 2,5 \times 10^8 \text{ W)}$

1.2.5 Input kinetic energy appears as sound energy / thermal energy in turbine due to friction / noise energy / raising the internal energy of the surroundings.

2. work done

3. power

4.1 The **work done** on an object by a **net force** is equal to the **change in the object's kinetic energy**.

4.2 $(E_p + E_k)_f = (E_p + E_k)_i$

$mgh_f + \frac{1}{2}mv_f^2 = mgh_i + \frac{1}{2}mv_i^2$

$m(9,8)(5) + 0 = m(9,8)(1,3) + 0$

$v_i = 8,52 \text{ m}\cdot\text{s}^{-1}$

OR

$W(\text{external forces}) = \Delta E_p + \Delta E_k$

$0 = mg(h_f - h_i) + (\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2)$

$-m(9,8)(5 - 1,3) = 0 - \frac{1}{2}mv_i^2$

$v_i = 8,52 \text{ m}\cdot\text{s}^{-1}$

5. A Speed increases with time.

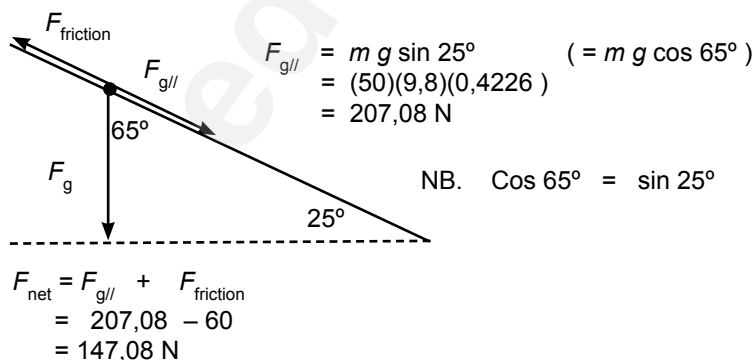
6. Kinetic energy

7. B Work done equals change in kinetic energy.

8. Gravitational potential energy.

9. D

10.1 Net force causing motion along the ramp:



10.2 Work done by net force:

$$W_{\text{net}} = F_{\text{net}} \Delta x \cos \theta = (147,08)(20)(\cos 0^\circ) \\ = (2941,66)(1) = 2941,66 \text{ J}$$

$$W_{\text{net}} = \Delta E_k \\ = E_{\text{kf}} - E_{\text{ki}}$$

$$E_{\text{kf}} = W_{\text{net}} + E_{\text{ki}} = 2941,66 + \frac{1}{2}(50)(2,5)^2 = 3097,91 \text{ J}$$

$$E_{\text{kf}} = \frac{1}{2}mv^2 \quad \therefore 3097,91 = \frac{1}{2}(50)v^2 \\ v = \sqrt{\frac{3097,91}{25}} = 11,13 \text{ m}\cdot\text{s}^{-1}$$

11. Yes

12. B

13.1 E_{mech} is not conserved. This is not an isolated system / there is friction present.

$$13.2 \quad E_k = K = \frac{1}{2}mv^2 \\ = \frac{1}{2}(55)(10)^2 \\ = 2750 \text{ J}$$

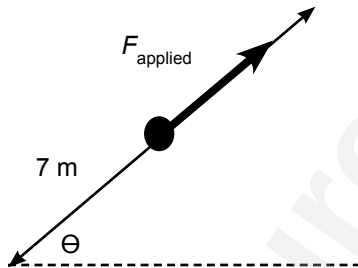
$$13.3 \quad W_{\text{non-conservative}} = \Delta E_k + \Delta E_p \\ F \cos \theta \Delta x = E_{\text{kf}} - E_{\text{ki}} + E_{\text{pf}} - E_{\text{pi}} \\ (18)(\cos 180^\circ)(8) = (\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2) + (mgh_f - mgh_i) \\ -144 = E_{\text{kf}} - \frac{1}{2}(55)(10)^2 + (55)(9,8)(1,2) - 0 \\ E_{\text{kf}} = 1959,2 \text{ J}$$

14.

D. No friction as he falls, so mechanical energy is conserved but momentum changes as he falls faster.

The safety net stops his downward speed and thus his momentum and it exerts an external force on him, which changes the mechanical energy.

15.



15.1

$$W_{\text{applied}} = F_{\text{applied}} \Delta x \cos \theta \\ 525 = F_{\text{applied}} (7)(\cos 0^\circ) \\ F_{\text{applied}} = 75 \text{ N up the slope}$$

15.2

$$F_{g//} = F_g \sin \theta = mg \sin \theta = (35)(9,8) \left(\frac{1,4}{7} \right) = 68,6 \text{ N}$$

$$15.3 \quad W_{\text{net}} = 0$$

$$\text{So } F_{\text{net}} = 0 = F_{\text{app}} + F_{g//} + F_{\text{friction}} \\ 0 = 75 - 68,6 + F_{\text{friction}} \quad (\text{as friction acts down the slope when the object moves up the slope})$$

$$-75 + 68,6 = F_{\text{friction}}$$

$$F_{\text{friction}} = -6,4 \text{ N} \\ = 6,4 \text{ N} \quad \text{Ignore the minus sign for a magnitude.}$$

16.1 gravitational potential energy

16.2.1

Direction of motion as positive :

$$F_{\text{net}} = ma$$

$$-30 = (3) a$$

$$a = -10 \text{ m}\cdot\text{s}^{-2}$$

$$v_f^2 = v_i^2 + 2 a \Delta x = (7)^2 + (2)(-10)(2)$$

$$v_f = 3 \text{ m}\cdot\text{s}^{-1}$$

OR

$$W_{\text{net}} = \Delta K$$

$$F \Delta x \cos \theta = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$(30)(2) \cos 180^\circ = \frac{1}{2} (3) v_f^2 - \frac{1}{2} (3) (7)^2$$

$$-60 = 1,5 v_f^2 - 73,5$$

$$v_f^2 = \frac{13,5}{1,5} = 9$$

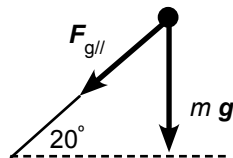
$$v_f = 3 \text{ m}\cdot\text{s}^{-1}$$

16.2.2



16.2.3

$$\begin{aligned} F_{g//} &= mg \sin 20^\circ \\ &= (3)(9,8) \sin 20^\circ \\ &= 10,06 \text{ N} \end{aligned}$$



$$W_{\text{net}} = \Delta K \text{ (or } \Delta E_k)$$

$$F_{g//} \Delta x \cos \theta = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$(10,06)(d) \cos 180^\circ = 0 - \frac{1}{2} (3) (3)^2$$

$$10,06 d = -13,5$$

$$d = 1,34 \text{ m}$$

17. ... is equal to the change in kinetic energy

18.1 0 N Zero no acceleration / constant velocity

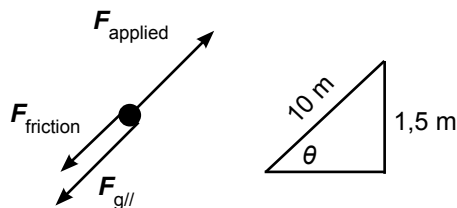
18.2 0 J Zero

18.3.1 Determine the applied force, F_{applied} , and then use $W_{\text{applied}} = F_{\text{applied}} \Delta x \cos \theta$

For equilibrium (constant velocity)

$$\begin{aligned} F_{\text{applied}} &= F_{\text{friction}} + F_{\text{gravity parallel to surface}} \\ &= F_{\text{friction}} + m g \sin \theta \\ &= 50 + \frac{(120)(9,8)(1,5)}{10} \\ &= 50 + 176,4 \\ &= 226,4 \text{ N} \end{aligned}$$

$$\begin{aligned} W_{\text{applied}} &= F_{\text{applied}} \Delta x \cos \theta \\ &= (226,4)(10)(\cos 0^\circ) \\ &= 2264 \text{ J} \end{aligned}$$



OR,

change in energy $\Delta U + \Delta K = \text{work done by external forces}$

$\Delta U + \Delta K = 0$ when we only consider the gravitational force

$\Delta U + \Delta K = W_{\text{external forces}}$ when a friction force and an applied force act

$$W_{\text{applied}} + W_{\text{friction}} = (U_f - U_i) + (K_f - K_i)$$

$$W_{\text{applied}} + F_{\text{friction}} \Delta x \cos \theta = mg(h_f - h_i) + 0 \quad (\text{since the velocity is constant } \Delta K = 0)$$

$$W_{\text{applied}} + (50)(10)(\cos 180^\circ) = (120)(9,8)(1,5 - 0)$$

$$W_{\text{applied}} - 500 = 1764$$

$$W_{\text{applied}} = 2264 \text{ J}$$

18.3.1 OR

use the work energy theorem $W_{\text{net}} = \Delta K$

$$W_{\text{applied}} + W_{\text{friction}} + W_{\text{gravity}} = \Delta K$$

$$W_{\text{applied}} + F_{\text{friction}} \Delta x \cos \theta + mg(h_f - h_i) = \Delta K$$

$$W_{\text{applied}} + (50)(10)(\cos 180^\circ) + (120)(-9,8)(1,5 - 0) = 0 \quad \text{as velocity is constant}$$

The wheelchair moves up and the gravitational force is down.

$$W_{\text{applied}} - 500 - 1764 = 0$$

$$W_{\text{applied}} = 2\,264 \text{ J}$$

18.3.2

$$W_{\text{applied}} = F_{\text{applied}} \Delta x \cos \theta$$

$$2\,264 = F_{\text{applied}} (10)(\cos 0^\circ)$$

$$F_{\text{applied}} = \frac{2\,264}{(10)(1)} = 226,4 \text{ N}$$

19.1 Energy

19.2 $\text{J}\cdot\text{s}^{-1}$ or $\text{N}\cdot\text{m}\cdot\text{s}^{-1}$

19.3 True

20. C

$$W = \frac{1}{2} m v^2 \quad \therefore W' = \frac{1}{2} m (2v)^2 = 4(\frac{1}{2} m v^2) = 4W$$

$$\text{Increase} = 4W - W = 3W$$

$$21.1.1 \quad W_{\text{nc}} = \Delta E_p + \Delta E_k$$

$$W_{\text{nc}} = (mgh_f - mgh_i) + (\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2)$$

$$7 \times 10^5 - 8,5 \times 10^4 = (10\,000)(9,8)(h_f - 0) + 0$$

$$6,15 \times 10^5 = (10\,000)(9,8) h_f$$

$$h_f = 6,28 \text{ m}$$

OR

Useful work done = gain in $E_p = mgh$

$$7 \times 10^5 - 8,5 \times 10^4 = (10\,000)(9,8) h$$

$$6,15 \times 10^5 = (10\,000)(9,8) h$$

$$h = 6,28 \text{ m}$$

21.1.2

$$W = F x \cos \theta$$

$$7 \times 10^5 = F(23)(1)$$

$$F = 3,04 \times 10^4 \text{ N}$$

$$20 \text{ km}\cdot\text{h}^{-1} = \frac{20}{3,6} = 5,56 \text{ m}\cdot\text{s}^{-1}$$

$$P = F v$$

$$= (3,04 \times 10^4)(5,56)$$

$$= 1,69 \times 10^5 \text{ W}$$

21.2

Surface must provide sufficient friction like sand.

Must be long enough for vehicle to stop.

22. Work is done when force and displacement are in the same direction.

23. A $W = P \Delta t$ Double the time, double the work done.

24. D

25.1

$$\sin 25^\circ = \frac{h}{AB}$$

$$h = AB \sin 25^\circ = (30)(0,38) = 11,5 \text{ m}$$

$\therefore$ Height is 11,5 m

$$25.2 \quad ME_{\text{at top}} = mgh + \frac{1}{2}mv_i^2 = (70)(9,8)(11,5) + \frac{1}{2}(70)(2,5)^2 = 7\,889 + 218,75 = 8\,107,75 \text{ J}$$

$$ME_{\text{at bottom}} = mgh + \frac{1}{2}mv_f^2 = (70)(9,8)(0) + \frac{1}{2}(70)v_f^2 = 35v_f^2$$

$$W_{\text{friction}} = F_{\text{friction}} \Delta x \cos \theta = (80)(30) \cos 180^\circ = -2\,400 \text{ J}$$

By the law of conservation of energy :

$$35v_f^2 = 8\,107,75 - 2\,400 = 5\,707,75$$

$$v_f^2 = 162,1$$

$$v_f = 12,8 \text{ m}\cdot\text{s}^{-1}$$

Work done by non-conservative forces W_{nc} (friction is the only external force)

$$W_{nc} = \Delta K + \Delta U$$

$$F_{\text{friction}} \Delta x \cos 180^\circ = \left(\frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 \right) + (mgh_f - mgh_i)$$

$$(70)(30)(-1) = \frac{1}{2}(70)v_f^2 - \frac{1}{2}(70)(2,5)^2 + (70)(9,8)(0) - (70)(9,8)(11,5)$$

$$-2400 = 35v_f^2 - 218,75 + 0 - 7\,889$$

$$35v_f^2 = -2\,400 + 7\,889 + 218,75 = 5\,707,75$$

$$v_f^2 = 163,1$$

$$v_f = 12,8 \text{ m}\cdot\text{s}^{-1}$$

$$W_{\text{net}} = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

$$= \frac{1}{2}(70)(12,8)^2 - \frac{1}{2}(70)(2,5)^2$$

$$= 5\,734,4 - 218,75 = 5\,515,6 \text{ J}$$

$$25.3 \quad P = \frac{W}{\Delta t} = \frac{5\,515,6}{10 \text{ s}}$$

$$= 551,6 \text{ W}$$

26.1 power

26.1 The **work done** on an object by a **net** force is equal to the **change in the object's kinetic energy**.

26.3.1

$$v_f^2 = v_i^2 + 2a\Delta x$$

$$= (0)^2 + (2)(2)(10)$$

$$= 40 \text{ m}\cdot\text{s}^{-2}$$

$$E_{kf} = \frac{1}{2}mv_f^2$$

$$= \frac{1}{2}(60)(40)$$

$$= 1\,200 \text{ J}$$

26.3.2

$$W_g = W_{\parallel} \Delta x \cos \theta$$

$$= mg \sin 25^\circ (10)(\cos 0^\circ)$$

$$= (60)(9,8) \sin 25^\circ (10)(1)$$

$$= 2\,485 \text{ J}$$

$$\text{OR} \quad W_g = W \Delta x \cos \theta$$

$$= mgh \cos 0^\circ$$

$$= (60)(9,8) (10) \sin 25^\circ (1)$$

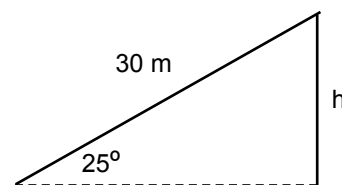
$$= 2\,485 \text{ J}$$

$$\text{OR} \quad W_g = -\Delta U$$

$$= -(0 - mgh)$$

$$= -[0 - (60)(9,8)(10)] \sin 25^\circ$$

$$= 2\,485 \text{ J}$$



26.3.3

OPTION 1:

$$W_{\text{net}} = \Delta E_k$$

$$W_{g \text{ (parallel to slope)}} + W_{\text{friction}} = \Delta E_k$$

$$2\,485 + W_f = 1\,200$$

$$W_f = -1\,285 \text{ J}$$

$$W_f = f \Delta x \cos \theta$$

$$\therefore -1285 = f(10) \cos 180^\circ$$

$$\therefore f = 128,5 \text{ N}$$

OPTION 2:

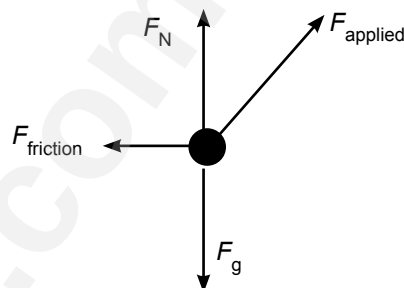
$$W_{\text{net}} = W_g + W_f$$

$$ma\Delta x = W_g + W_f$$

$$(60)(2)(10) = 2\,485 + W_f$$

$$W_f = -1\,285 \text{ J}$$

27.1



27.2

$$W = F \Delta x \cos 90^\circ = 0 \quad \text{OR} \quad \text{The angle between the force and displacement, } \Delta \mathbf{x}, \text{ is } 90^\circ.$$

Thus the crate moves horizontally and the forces act vertically.

27.3

$$W_{\text{net}} = W_{\text{applied}} + W_{\text{friction}}$$

$$= F_{\text{applied}} \Delta x \cos \theta + F_{\text{friction}} \Delta x \cos \theta \quad (F_{\text{applied}} \text{ must be in the direction of motion} = 50 \cos 30^\circ)$$

$$= (50)(6)(\cos 30^\circ) + (20)(6)(\cos 180^\circ)$$

$$= 259,81 + (-120)$$

$$W_{\text{net}} = 139,81 \text{ J}$$

$$27.4 \quad W_{\text{net}} = \Delta E_k = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2$$

$$139,81 = \frac{1}{2} (30) v_f^2 - 0$$

$$v_f = 3,05 \text{ m}\cdot\text{s}^{-1}$$

27.5 Greater than.

The horizontal component of the force or the force in direction of motion will now be greater.

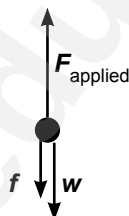
As θ decreases when $\cos \theta$ increases.

28.1 Power

28.2 D

29.1 The work done on an object by a net force is equal to the change in the object's kinetic energy.

29.2



29.3 Gravitational force or weight of soldier.

29.4

$$W_{\text{net}} = \Delta K$$

$$W_{\text{applied force}} + W_{\text{gravitational force}} + W_{\text{friction}} = \Delta K$$

$$F_{\text{applied}} \Delta y \cos \theta + F_g \Delta y \cos \theta + W_{\text{friction}} = \Delta K$$

$$(960)(20)\cos 0^\circ + (80)(9,8)(20)\cos 180^\circ + W_{\text{friction}} = 0$$

$$19\,200 - 15\,680 + W_{\text{friction}} = 0$$

$$W_{\text{friction}} = -3\,520 \text{ J}$$