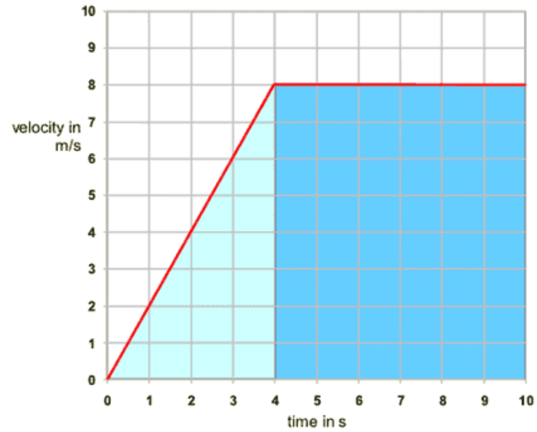
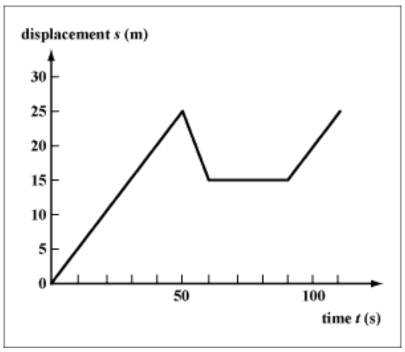
02 Mechanics review answers

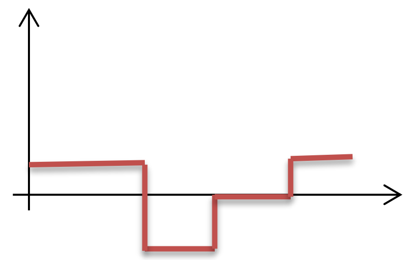
Part A: Kinematics:



1. For the graph on the right state:
   a. The instantaneous velocity at t=3seconds: **$6 ms^{-1}$**
   b. The average v first 4s: **(u+v)/2 = 8/2 = $4ms^{-1}$**
   c. a during the first 4s: **= gradient =(v-u)/t = 8/4 = $2ms^{-2}$**
   d. Total distance travelled: = area = **0.5*4*8+6*8=64m**



2. Velocity-time graph for the motion represented on the graph. The graph should be as shown:
Step changes in velocity from +0.5 to -1.0, to 0.0 to +0.5 ms^{-1}



3. The graph you have drawn for question 5 is a simplification. **Step (instantaneous) changes in v are not possible because infinite acceleration is not possible.**

4. State what the area under an acceleration-time graph represents. **Change in velocity**
5. State the condition under which the equation ***s = (u+v)t/2*** is valid. **Constant acceleration**
6. A ball is dropped near the surface of the Earth and hits the ground 3 seconds later.
   a) (Ignoring air resistance) Ball speed when it hits the ground? **Δv = at = gx3 = 29.4 ms^{-1}**
   b) How far will the ball have travelled and what is its average speed?

s = (u+v)t/2 = 29.4x3/2=44.1m, average velocity = 14.7 ms^{-1}

   c) After how long did it take the ball to travel 9.81 metres?

s = ut + $0.5at^2$, u=0 so t^2=s/0.5g = 9.81/(0.5*9.81) = 2, t=1.41s

   d) How fast was the ball travelling after it had fallen 19.62 metres?

$v^2 = u^2 + 2as$, u=0 so v = √(2 x 9.81 x 19.62) = 19.62 ms^{-1}

7. Two balls are in motion. Ball A is travelling upwards at $12ms^{-1}$ at an elevation of 30^0. Ball B is traveling vertically downwards at 2 ms^{-1}. What is the velocity of A relative to B?

A relative to B vertically = 12sin(30) + 2 = 8 $ms^{-1\ (up)}$, A relative to B horizontally = 12cos30 = 10.39 ms^{-1}

In magnitude and direction: Magnitude = $\sqrt{(8^2 + 10.39^2)}$ = $13.1ms^{-1}$, Elevation = $\tan^{-1}(8/10.39) = 37.6^0$

Part B: Forces and Dynamics

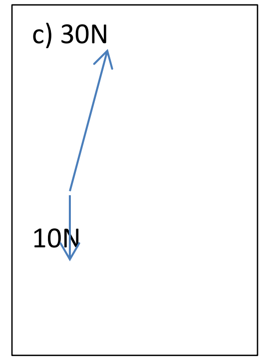
1. A 1kg block is sliding along a table. There is no force pushing it.
    a. Draw a force diagram for the block, labeling the forces and describe its motion.

10N Weight(mg) down 10n Normal (upthrust) up, Friction acting against motion. Decelerating

    b. The block falls off the edge of the table, draw a force diagram for the block now.

10N Weight(mg) only

    c. The block is caught and during the catch max force on the ball was 30N, 10^0 to the vertical. Draw the force diagram now and calculate the acceleration.



Resultant force is 30sin(10)=5.2N horizontal and 30cos(10)–10=19.5N vertical.

Magnitude = $\sqrt{(19.5^2+5.2^2)}$ = 20.2, direction tan-1(5.2/19.5)=15^O from vertical.

Acceleration = Force/Mass, Mass=1 so 20.2ms^{-2} at 15^O from vertical

2. For conservation of linear momentum….. **No external forces**
3. A rifle can shoot a 4.20 g bullet at a speed of 965 ms^{-1}. The bullet is fired into a 50.0 kg torso with vest of 2.5kg.

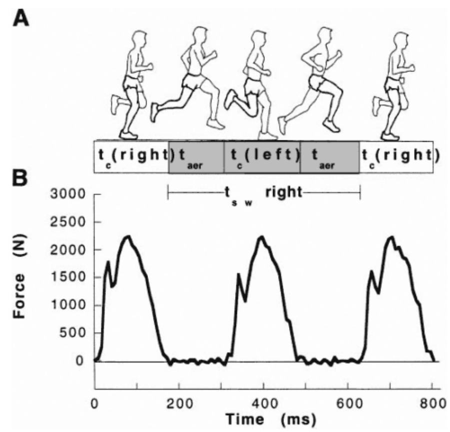
    $P_{before} = P_{after}$

    0.0042 x 965 = v x (50+2.5+0.0042) so v = 0.077ms^{-1}

4. Estimate the (vertical) impulse from the graph opposite.

    Impulse = FΔt = 1700x170x10^{-3}s = 289Ns

    The 70kg person will change velocity by 289/70 = 4ms-1 but the ground will be almost unaffected. Apart from a mini-seismic wave travelling out from the impulse.



Part C: Work, Energy and Power

1) Sledge pulled with 10N at an angle of 30^o for 30m how much work is done?

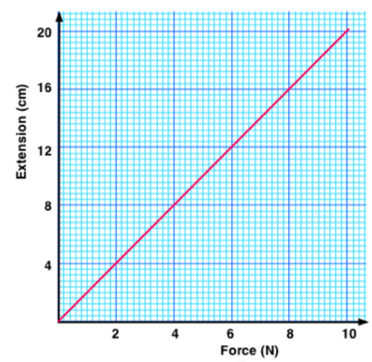
    W=Fscosθ = 10x30xcos(30) = 260J

2) a) How much work is done stretching spring 0.2m?

    W for 0.2m stretch = Fs (using average F) = 10x10=100J

    Or by area under graph = 0.5x10x20 = 100J

    b) What type of energy is transferred to the spring? **E_p**



3) A 1100kg lorry travelling at 24ms^{-1} collides with a 600kg car travelling at 19ms^{-1} in the same direction.

    a) After the collision the new speed of the car is 23m/s what is the new velocity of the lorry?

    $P_{before} = P_{after}$ so….1100x24 + 600x19 =1100v + 600x23

    V = (1100x24 + 600x19 - 600x23)/1100 so v = 21.8ms^{-1}

    b) Calculate the total amount of kinetic energy before and after the collision.

E_k = ½ mv^2 ➔before = 316800+108300 = 425,000J, after = 261382+158700 = 420,000J (NB 3 s.f.)

3) An 80kg skier starts from a velocity of 0.5ms^{-1} at the top of a slope 35m high. Friction on the skier is 20N and the slope is 200m long how fast is the skier travelling at the bottom?

    E_k gained = Ep – work done against friction = mgh – Fs = 80x9.81x35 – 20x200 = 23468J

    ½ mv^2 = 23468J so v = $\sqrt{(23468x2/80)}$ = 24.2 ms^{-1}

    If the skier uses a drag lift to get back up the slope how much work does the drag lift do if the average frictional force remains 20N? **mgh + Fs = 80x9.81x35 + 20x200 = 31486J = 31500J**

Part D Uniform Circular Motion.

1. Space station 450m diameter and rotating
   a. Add an arrow to show the direction of the force on person A.
   b. State the magnitude and direction of the acceleration at the perimeter in order to produce a gravitational effect equivalent to 0.5g. **towards the centre: 0.5x9.81 = 4.91 ms^{-2}**
   c. Calculate the velocity at the edge of the space station required to create a gravity effect equivalent to 0.5g.
   $a = v^2/r$……so $v = \sqrt{(0.5x9.81x225)} = 33.2ms^{-1}$
   d. Acceleration at the perimeter. **0.5x9.81 = 4.91 ms^{-2}**
   e. This acceleration is created without the need for a resultant force on the space station?
   The acceleration needed on the opposite side is in the opposite direction so the forces balance out meaning no resiltant force on the space station as a whole.