Physics SL

IB1 Examination

- Paper 2 -

7 Questions

Friday 13 Dec. 2024

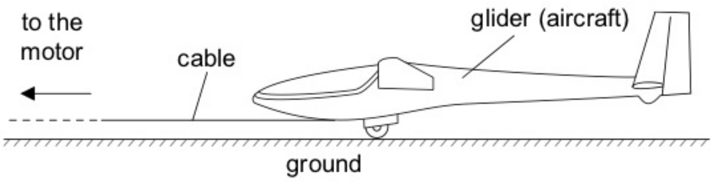
Maximal time : 1h45

Name :

ANSWERS

Question 1 *[/6 marks]*

To be launched, a glider is uniformly accelerated from rest by a cable pulled by a motor that exerts a horizontal force on the glider throughout the launch.



1) The glider reaches its launch speed of 27.0 ms^{-1} after accelerating for 11.0s.

Assume that the glider moves horizontally until it leaves the ground.

The total distance travelled by the glider before it leaves the ground

is $d = \frac{v+u}{2}t = \frac{27}{2}11 = \boxed{148.5m}$

2) The glider and pilot have a total mass of 492 kg.

During the acceleration the glider is subject to an average resistive F_f force of 160 N.

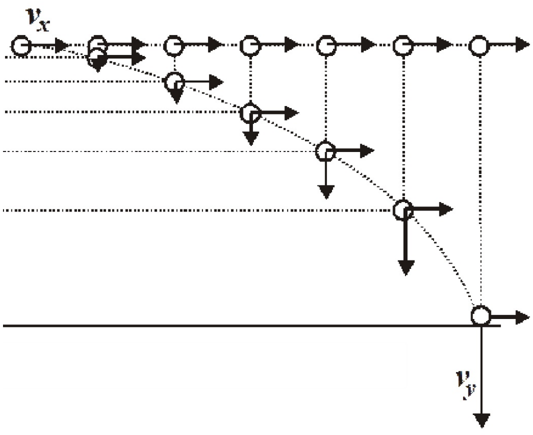
The average tension in the cable as the glider accelerates is given by Newton's second Law:

$$\sum \vec{F} = m\,\vec{a} \Rightarrow \underbrace{m\,\vec{g} + \vec{F_R}}_{\text{zero}} + \vec{F_f} + \vec{F_M} = m\,\vec{a} \quad \Rightarrow -F_f + F_M = 492 \times \frac{27}{11} = 1208N$$

$$\Rightarrow F_M = 1208 + 160 = \boxed{1368\text{N}}$$

Question 2 *[/9 marks]*

An archer send an arrow horizontally （アーチェリー。矢印は水平に投影されます。）



Horizontally : The initial value of V_x is 12m/s.

Vertically : The initial value of V_y is 0 m/s,

The acceleration is $a = g = 9.81 m s^{-2}$, you can take $a = g = 10 m s^{-2}$.

1) The *horizontal* component of the velocity is *constant* because no fore acts on this direction.

2) The *vertical* component of velocity is <u>not</u> constant, because there is a force in the vertical direction. This force ($w = mg$) is the *gravitational interaction* between the arrow and the Earth. It is constantly oriented *downward*. (more precisely toward the center of the planet).

3) The time it takes for the arrow to reach the ground depends of the initialé hight h_o

we solve the equation $h_o = \frac{1}{2} g t^2$ then $\boxed{t = \sqrt{2 g h_o}}$

4) The *horizontal distance* that the arrow travels before reaching the ground is $V_x \cdot t$

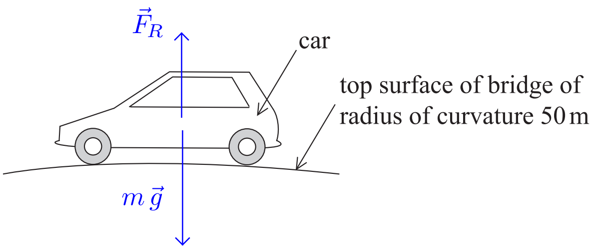
whit V_x=12m/s. As we don't know the value of h_o we cannot give any value for the result,

but supposing for example that $h_o = 1.6m$, the result would be $d = 12 \cdot \sqrt{2 \times 9.8 \times 1.6} = \boxed{67.2m}$

Question 3 [/7 marks]

This question is about circular motion.

The diagram shows a car moving at a constant speed over a curved bridge. At the position shown, the top surface of the bridge has a radius of curvature of 50 m.



(a) Explain why the car is accelerating even though it is moving with a constant speed. *[2]*

That is because even if the speed is constant, the velocity is not constant.
(because the direction of the motion is changing)
The acceleration is the instantaneous rate of change of the velocity.
Hence the acceleration is not zero here.

(b) On the diagram, draw and label the vertical forces acting on the car in the position shown. *[2]*

(c) Calculate the maximum speed at which the car will stay in contact with the bridge. *[3]*

$\sum \vec{F} = m\,\vec{a}$

$F_R - mg = -m\frac{v^2}{r}$

considering $F_R = 0$: $mg = m\frac{v^2}{r}$

$\Rightarrow g = \frac{v^2}{r} \Rightarrow v = \sqrt{gr} = \sqrt{10 \times 50} = \boxed{22.35\ m s^{-1}}$

Question 4 [/6 marks]

Four persons are pushing a car of mass 1400 kg.

質量1400kgの車を4人で押す Cuatro personas empujan un coche con una masa de 1400 kg.

The two parents have forces 120 N and 90 N

2 つの親の力は 120 N と 90 N です。 Los dos padres tienen fuerzas de 120 N y 90 N.

The two children have forces 67 N and 43 N

There is a *friction force* (fuerza de fricción 摩擦力) of 40 N

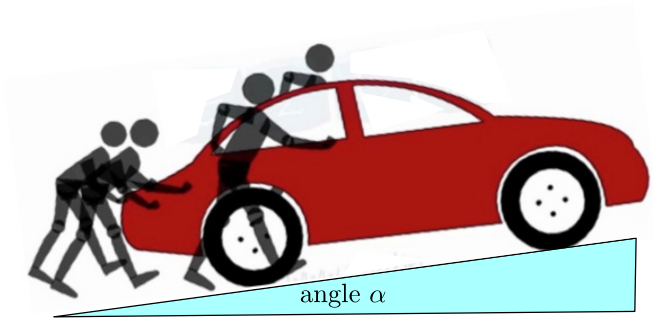
1) The *acceleration* of the car is given by Newton's second Law : $\sum \vec{F} = m\,\vec{a}$

Here with $\sum \vec{F} = \underbrace{m\,\vec{g} + \vec{F_R}}_{\text{zero}} + \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \vec{F}_4 + \vec{F}_f$

then $120 + 90 + 67 + 43 - 40 = 1400\,a \quad \Rightarrow a = \frac{280}{1400} = \boxed{0.2\,\text{ms}^{-2}}$

2) Now the same people push the same car (with the same forces)

but the road has an inclination of angle $\alpha = 1^0$.



3) In that situation, it will be fore difficult to push the car because gravity will exert a force which acts in the opposite direction to the forces of the four persons.

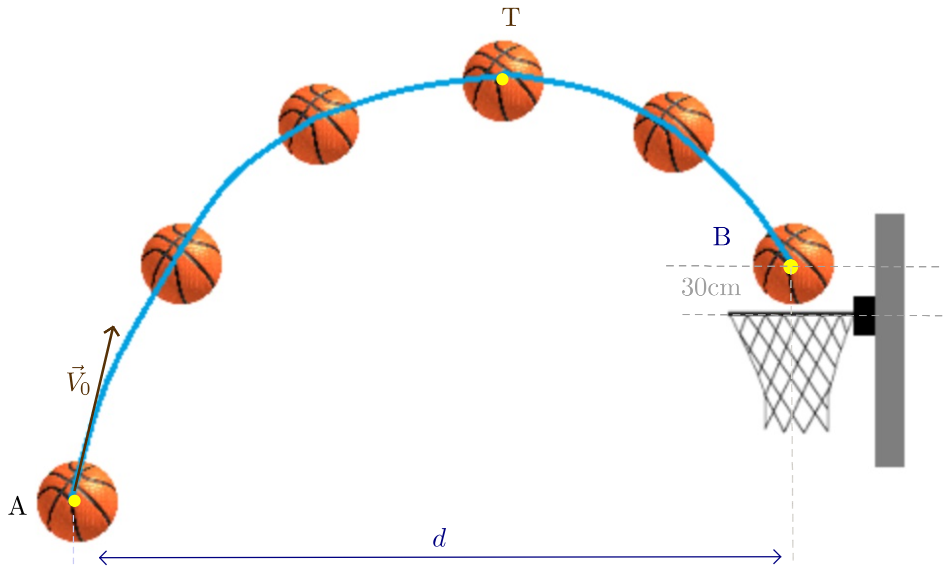
We will see that this force is $m\,g\,\sin(\alpha)$, then it doesn't exist when $\alpha = 0$.

Question 5 *[/13 marks]*

A basket ball is sent with the initially velocity $\vec{V_0} = \begin{pmatrix} 3 \\ 12 \end{pmatrix}$,

that means : 3m/s *horizontally* and 12 m/s *vertically*, as show in the picture.

The initial position A of the ball (projected by a player) is $x = 0$, at 1.7m height.



1) The trajectory of the ball is a *parabola* .

2) The time it will take to the ball to reach the top position T is given considering $v_y = 0$ at T

$v_y = v_{y0} + a t \Rightarrow 0 = 12 - 10 t \Rightarrow \boxed{t = 1.2s}$

3) The coordinates (that is x and the hight y, in m) of position T are

$x = 0 + 3 \times 1.2 = \boxed{3.6m}$

$y = 1.7 + 12 \times 1.2 - \frac{1}{2}10 \times 1.2^2 = 1,7 + 14.4 - 7.2 = \boxed{8,9m}$

4) Position B is 30 cm above the basket net bar.

The horizontal displacement of the ball from A to B is $d = 6.7m$

Find the hight of the basket net bar.

The time for moving from A to B is solution of

$d = v_{x0}\, t \Rightarrow t = \frac{d}{v_{x0}} = \frac{6.7}{3} = 2.233s$

At this time, the hight is $y = 1.7 + 12 \times 2.233 - \frac{1}{2}10 \times 2.233^2$=3.56m

Conclusion: The hight of the basket net bar is 30cm above 3.56m then it is $\boxed{3.26\text{m}}$

Question 6 [/5 marks]

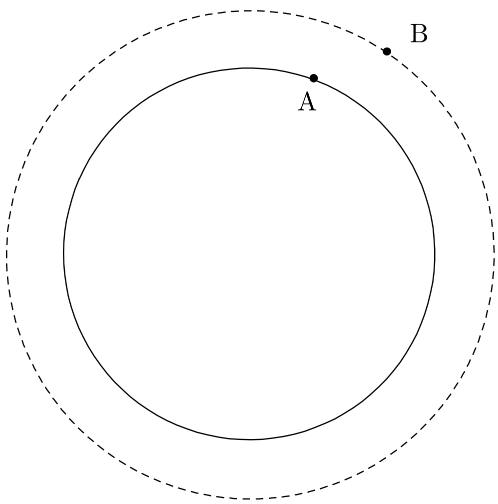
A hare and a tortoise are having a race along a 60 m track.
At time $t=0$, the tortoise starts running at 1m/s.
The hare sleeps a long time.

Finally at time t=50s he starts running,
with a constant acceleration $a=1$m/s.

When the hare starts moving, the tortoise has moved of $d=v_T t=1\times 50=50m$ and continue moving so that
$x_T=50+t$
The position of the hare is given by
$x_H=0+0t+\frac{1}{2}1t^2$
Then for reaching the final arrival position at 60m:
$60=50+t \quad \Rightarrow \boxed{t=10\,s}$ for the *tortoise*
$60=\frac{1}{2}1t^2 \Rightarrow t=\sqrt{120}\cong \boxed{10.95s}$ for the *hare*.

Conclusion : *tortoise* arrives first !

Question 7 [/10 marks]



Let two bodies A and B are moving on two horizontal circles or radius $R_1=2m$ and $R_2=2.5m$ with constant speeds.

1) If the frequency of rotation of A is 8Hz, and if both A and B have the *same angular speed* $(\omega_1=\omega_2)$ then:

a) The *speeds* are : $V_A=\omega R_1$ and $V_B=\omega R_2$
where $\omega=2\pi f=16\pi\approx 50.27\frac{r}{s}$ is the common *angular speed*.
Hence : $V_A=100.5ms^{-1}$ and $V_A=125.7ms^{-1}$

b) The *period* of each one is the same : $T_A=T_B=T=\frac{1}{f}=0.125$Hz

2) If now A and B have *same speed*: $v_1=v_1=10ms^{-1}$ then

a) Each one has a specific *angular speed* given by $\omega=\frac{v}{r}$
then $\omega_1=\frac{10}{2}=5\frac{r}{s}$ and $\omega_2=\frac{10}{2.5}=4\frac{r}{s}$

b) As the period of B is $T_B=\frac{2\pi}{\omega_2}=1.57\,s$, the number of turns completed by B in 50.27sec, is $\frac{50.27}{1.57}\cong 32$

c) For completing 32 turns, it would take to A a time of $32T_A$, that is $32\frac{2\pi}{\omega_1}\cong 40.2$ sec.