mechanics

- motion
  - 大三式 $\begin{cases} v=u+at \\ s=ut+\frac{1}{2}at^2 \\ v^2-u^2=2as \end{cases}$ → 抛体运动 $a=g\downarrow$ → 自由落体 / 上抛 / 下抛 / 平抛 / 斜抛
  - 图像
    - s-t：面积⊥ 斜率
    - v-t：面积⊥ 斜率
    - a-t
- force
  - N_1 / N_2
    - 定性题 $\Delta v \neq 0 \leftrightarrow \Sigma F \neq 0$
    - 计算题 $\Sigma F = ma$ 合外力方向与加速度同向
  - N_3 : A $\overset{\text{equal. opposite}}{\rightleftharpoons}$ B
    - same size
    - same type
    - different body
    - opposite direction
- $\vec{M}=\vec{d}\times\vec{F}$ moment
  - $M = F \times d_\perp$ (moment arm)
  - principal of moments : equilibrium
  - centre of gravity

$F \rightarrow \Sigma F \rightarrow a \rightarrow v \rightarrow s$

$F/d_\perp \rightarrow M \rightarrow \Sigma M \rightarrow a$

def.

N_1 every object continues in its state of rest or uniform motion in a straight line, unless an external force acting on it

N_2 the acceleration of an object is directly proportional to the net force acting on it.

principal of moments : the sum of anticlockwise moment = the sum of anticlockwise moment, if no external force acting on it

gravatational field strength: gravatational force per unit mass

守衡

- energy
  - work(power) $W_F = \vec{F}\cdot\vec{s} = Fs\cos\theta$
  - work-energy principle
    - $W_W = -\Delta GPE$ > 保守力
    - $W_F = -\Delta EPE$
    - $W_f = -\Delta Q$ — 非保守力
    - ------
  - conservation of energy $\Delta E_{sh}\downarrow = \Delta GPE\uparrow + \Delta Q\uparrow + \Delta KE\uparrow$
- momentum
  - N_2 $\Sigma F = \frac{\Delta p}{\Delta t}$ constant m → ma
  - conservation of momentum ← $N_2 + N_3$
    条件：内力远大于外力 情境：eg. 短时间内撞击

$\vec{F}(\Delta s) \rightarrow W_F(+/-) \rightarrow \Delta E(\downarrow/\uparrow) \rightarrow$ cons $\rightarrow \Delta E'(\uparrow/\downarrow)$

$\vec{F}(\Delta t) \rightarrow \int \rightarrow \Delta p(+/-) \rightarrow \Delta p'(-/+)$

Motion

用于求运动

① 大三式　条件：匀加速

② 能量守衡　条件：无条件，不能涉及不可计算的能量

③ 动量守衡　条件：$F_{ext} \ll F_{int}$ {碰撞 / 爆炸

Force

$F_{主动} \rightarrow F_{被动} \rightarrow \Sigma F \rightarrow a/\Delta v \rightarrow v \rightarrow s$

N_3 相互作用力

ΣF (合外力)

静止 / 运动状态 (explain)　运动 / $F=ma$ (calculate)

Moment

F & 力臂 $r_\perp \longrightarrow$ Moment $\longrightarrow \Sigma M$ (一般为0)

Work & Energy

$F \longrightarrow W \longrightarrow \Delta E \longrightarrow$ conservation

↑ 分清做正功还是负功

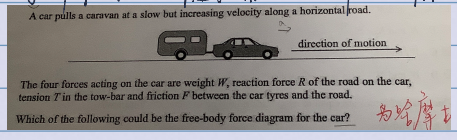
Momentum

$\Sigma p = 0$ cons of P $\rightarrow \Sigma p' = 0 \rightarrow$ P等反向 $\rightarrow m_A < m_B \rightarrow v_A > v_B$

Force

- 技巧

1. 判断摩擦力：看直接触力　ep. ↓只看轮子



2. 描述 motion/force change：变化大小+变化方向

3. 算角度，注意 D 还是 R

- 知识点

1. 导致物体运动改变原因：N_1.

论述：According to N_1, the resultant force acting on … cause it accelerate

2. { resultant force 合力
   { external force 核外力

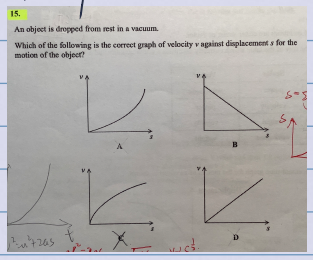
Motion

- 审题：看清 distance / displacement
  看清是否有 air resistance

- 计算：单位换算 $1 m s^{-1} = 3.6 km h^{-1}$

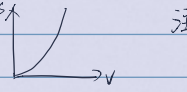
- 技巧

1. 速量分析



$v^2 = u^2 + 2as$, $u=0 \rightarrow v^2 = 2as$

$s = \frac{1}{2}v^2$



注意横纵坐标

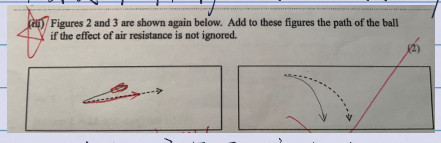
2. 计算题明确矢量方向

3. 论述题 可从公式入手分析对某物理量的影响

- 知识点

1. air resistance 与运动反向

不会改变物体初速度方向，只会改变初速度大小



运动方向改变原因：核外力方向与运动方向不同向

2. 失重原因

no reaction force, so only weight act on

未知 → 已知

- 论述题模板

vertical component of …

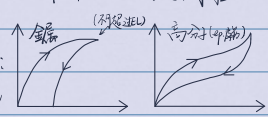
range + height

explain path:

$F \rightarrow \Sigma F \rightarrow a \rightarrow v \rightarrow s$ { $s_H \rightarrow$ range / $s_V \rightarrow$ height

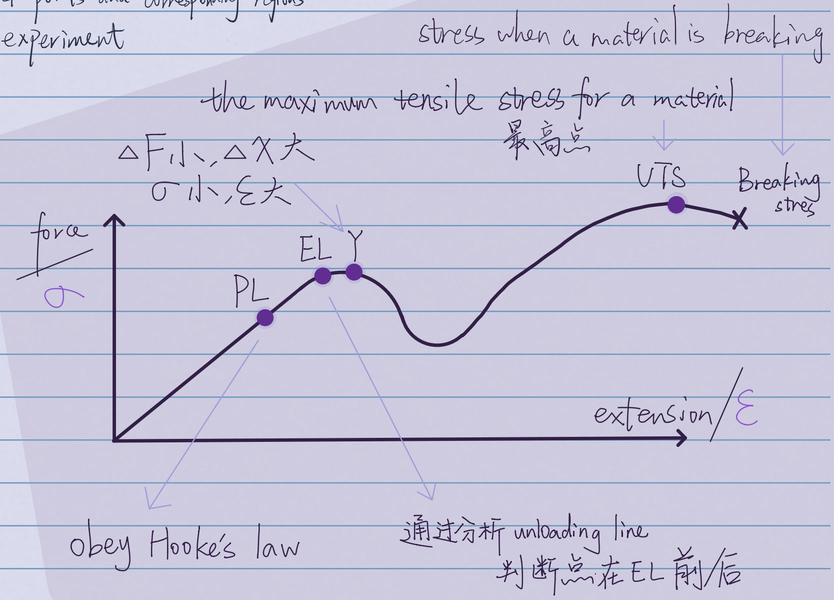
路程受 component of air resistance 影响

- material
  - fluid ($F \to \Delta V$)
    - flow (流体运动)
      - laminar
        - def. flow with no mixing in layers
        - cause: no change in velocity
      - turbulent
        - def. flow with mixing in layers
        - cause: change in velocity
        - effects
          - Drag↑
          - eddies↑
      - 减小 turbulent: streamline/smooth surface
    - forces (物体在流体中运动)
      - $\Sigma F = 0$ ↓ terminal velocity
      - ↑ Upthrust — 排斥
        - 定义: $F_浮 = G_排$
        - $U = \rho_{fluid} g V_{displaced}$
      - Drag — 影响因素 (从公式中找答案)
        - size
        - V_{ball}
        - η_{fluid}
          - liquid $T\uparrow \to \eta \downarrow$
          - gas $T\uparrow \to \eta \uparrow$
        - turbulent
        - $\longrightarrow D \to \Sigma F \to a \to V$ (rate of flow)
      - $D = 6\pi \eta r V$ 条件: 层流 {小球, 慢速}
      - 产生条件
        - 有速度才有阻力
        - 与运动方向相反
      - ↓ Weight — 地球 $W = \rho_{solid} g V_{solid}$
      - 分析物体沉浮 直接因素是力 不是 ρ
  - solid ($F \to E_n$)
    - $F - \Delta x$ graph
      - Hooke's law $F_{res} = -k \vec{\Delta x}$
      - EPE = area
        - $= \frac{1}{2} F x$
        - 数格/近似面积
      - unloading line
        - area: 存在回滞现象 (hysteresis) 反弹时的力, 一定小于拉力
        - slope & intercept:



(EL很大. 难达到. 会回到原长)

    - $\sigma - \varepsilon$ graph
      - 归一化 $\sigma = E\varepsilon$
      - 4 points and corresponding regions
      - experiment



def.

Young's modulus: In Hooke's law region, $\text{young's modulus} = \frac{\text{stress}}{\text{strain}}$

viscosity: resistance of a fluid to flow

terminal velocity: velocity when resultant force = 0

tensile strength: maximum stress when material is extending

三种阻力
- air resistance 气体
- drag force 流体
- friction 固体

Fluid

知识点

1. 阻力产生条件：有速度才有阻力

2. Viscosity

$$\begin{cases} \text{gas}: \eta \propto T & T\uparrow \to \eta\uparrow \\ \text{liquid}: \eta \propto \frac{1}{T} & T\uparrow \to \eta\downarrow \end{cases}$$

3. 为啥 upthrust 可忽略

$W = \rho_{人} V_{人} g \quad V = \rho_{空气} g V_{人} \quad \rho_{人} \gg \rho_{空气}$

要回答相对大小，绝对大小不准确

4. 为啥大水滴末速度大？

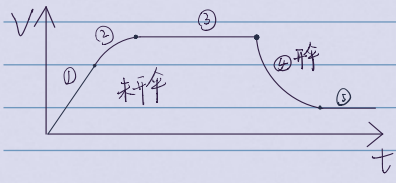
$D = 6\pi\eta r V \quad D \propto r$

$W = \frac{4}{3}\pi r^3 \rho g \quad W \propto r^3$

$\to 6\pi\eta r V = \frac{4}{3}\pi r^3 \rho g \to V \propto r^2$

$r\uparrow V\uparrow$

5. 跳伞



① only W act $\to a = g$

② v 与 drag force 成正比

③ $D = W$ $a = 0$ terminal velocity

④ $D - W = ma$

$\text{tur} \to V\downarrow \to D\downarrow \to a\downarrow$

⑤ $D = W$ $a = 0$ terminal velocity

$m\uparrow \to$ terminal velocity $\uparrow$

原因：$\text{Drag} = mg$

↳ 与 V^2 成正比

逻辑关键：力

力是导致速度变化的根本原因

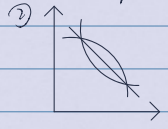
技巧

1. 画图题

① 先判断成正/反比

② 判断选哪条线：

分析与 x、y 轴是否有交点



Solid Material

知识点

1. Hooke's law 条件

before proportionality limit

超出区域 ① won't return ② Δx 与 F 不成正比

2. Hooke's law + 三点 def.

behavior of wire 包括 PL. EL. Y. 没有 UTS

PL: before this point, force is proportional to extension

EL: before this point, material will return to original shape when force is removed

Y: beyond this point, a small increase in force cause a large increase in extension

3. $\sigma - \varepsilon$ 图与 $F - \Delta x$ 图

	$\sigma - \varepsilon$	$F - \Delta x$
斜率	YM (物质 stiffness)	物体 stiffness
面积	energy stored per volume	Eel

实验题

● 画图法流程

1. objective { define a quantity A
   verify relationship between A & B
   ↓ equation
2. measurements { constants
   variables { independent 自变
   dependent 因变
   ↓
3. apparatus { 量程
   精度 percentage uncertainty = 精度/测量值 ← 控制在2%
   ↓
4. repeat measurement b. 中要在画图前完成
   ↓
5. plot a graph of 因 / 自 y-x
   需先将原始数据变成线性关系
   (draw the best fit line)
   ↓
6. determine the gradient (of linear part)
   Q = gradient

● 实验精度

准确 accurate = valid measurements close to true value

random error 不可避免 { repeat & average
repeat & graph ← 取 best fit line

精确 precise = reliable the repeated measurements are close to each other

systematic error 可避免 { zero error 归零
parallex error 视差
human reaction time 反应时间

精度 precision = resolution the smallest detail that 器材 can distinguish

误差概算 percentage uncertainty (u%) = 精度/测量值 → { = resolution 能测出的最小值
= (max − min)/2 ← range

易产生的误差 ① friction ② human reaction time
③ hard to read … in a short time

● 错误值

比较极值与其它值的差距，若小，便为错误值

● 文字题

describe 仅描述，不深层分析
ep. describe v-t graph 不分析力

state

explain 说明+解释（根据/结合图像）

suggest how 不用解释

"文"题 论点+论据+具体话题
注意连接词，不要列"①②"

2020.1 49

7. 动量守恒
P为vector. $P=mv$, v要带+/-
守恒式 $m_1v_1+m_2v_2=m_1v_1'+m_2v_2'$
转移式 $|m_1\Delta v_1|=|m_2\Delta v_2|$

11. 实验题
若涉及到画图. x-y轴上物理量要带单位

确定垂直：使用 set square

13. 力矩题 ：分析一物体不平衡的原因
① 重心not in the pivot
② anticlockwise > clockwise

14. 固体材料 ： σ-ε 图像描述
特殊点：ep. UTS ： UTS larger → stronger
斜率 ：斜率越大，越stiffer 斜率 = young's modulus
面积 ： energy per volume

16. 实验题 ：测定
用尺子读长度要有一位估读

17. 能量守恒
a(i) ① 用公式辅助解释物理量间关系
② 减少变量.
$\Delta EPE=\Delta KE \rightarrow v=\sqrt{2gh}\,\Delta x$

a(ii) 陌生的计算题多从公式，图表入手

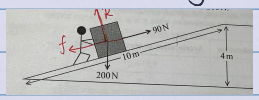
b. σ-ε 中，线开始curve 是 beyond PL，及 EL

18. 固体材料
a. Y模定义
b. ① 找错误值
② 标准单位

19. N3 论述题
☆ 明确指出"谁"给"谁"的力

2019.1 48

4. 能量 —— 求efficiency
$efficiency=\frac{W_{有}}{W_{总}}$



← 在此情境中，速度变化对efficiency无影响
KE → GPE，所有KE都转化成了GPE
不用考虑过程中的KE变化

14. 受力分析 —— 鸡蛋上沙发时分解Vs气体进入
技巧：从两个statement的共同点（m的变化）出发考虑
分解 m↓ → W↓ → U↑ → W → Σ于何上

15(c) 动量守恒
P撞Q，两者一起运动 $P_P=P_P'+P_Q$
P no initial speed 指碰撞前的速度
=总 P = m_P

16 (b) 抛体运动
def free fall : only weight act on

17(a) 固体材料
YM条件及符合 Hooke's law
求YM必须为直线段斜率

17(c) 实验题 —— σ-ε 图像描述
斜率 YM，YM越大，物体越 stiff
面积 energy stored per volume
特殊点/最高点 EL优先描述，因为它表示材料的重要特征
PL
Y
UTS
↳ beyond : won't return
within : can return

2019.6 41

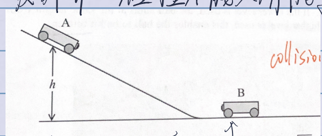
2. 单位
"s"在物理量中表示距离
在单位中表示s

3. 实验题——测量
量导线的横截面积 测的是直径，算面积时要记

7. N3
只能涉及到两个力，区分于平衡的式子

9. 大二式——下落
路程速度分析
$s=\frac{1}{2}at^2$ $S_{1秒}:S_{2秒}=\frac{1}{2}a:\frac{1}{2}a\times4=1:4$

12. 能守&动守求运动
这样开的碰撞不能只用能守



分段分析

能守 碰撞时:动守

14. 质量越大，表面积越大，阻力越大

15.a. σ−ε图像涉及到对比时，要明确指出重要点(ep. UTS)对应的量

b. fracture前能承受的最大力
找UTS，而不是breaking point

2019.10 54

3. 分析力的变化
一. 判断是否在平衡状态 二. 列等式

17. 固体材料——F−Δx 图像题
- 斜率 stiffness
- 面积 Eel.
- 特殊点 UTS greater breaking stress

作比较时取点要控制变量，保证F或Δx相等

18 (a) $W=\rho gV$

2016. 卷1

4

A bubble of air is rising through a vertical column of water.

Which statement, about the motion of the bubble, is correct to a good approximation?

- A The bubble has a constant velocity because its weight equals the viscous drag.
- B The bubble has a constant velocity because the upthrust is equal to the viscous drag.
- C The bubble has an acceleration because its weight is greater than the upthrust.
- D The bubble has an acceleration because the viscous drag is greater than the upthrust.

bubble in W 忽略

$W_{bubble} = \rho_{air} g V$ $U_{bubble} = \rho_{water} g V$

$\rho_{air} \ll \rho_{water}$ W_{bubble} 很小，可忽略

5. 实验题

重复实验取平均后 in 有效位数与代入前 in 有效位数保持一致

6. SI base

kg. m. s ...

11

Comment

"If a car was going faster, it would have better fuel economy. A lot of modern cars have engines that are more efficent at 200 km h^{-1} than at 100 km h^{-1}."

Reply

"You confuse efficiency with fuel consumption. You cannot get better fuel economy at higher speeds."

Justify the statement in the reply.

v↑ → F↑ → P↑ → fuel consumption↑

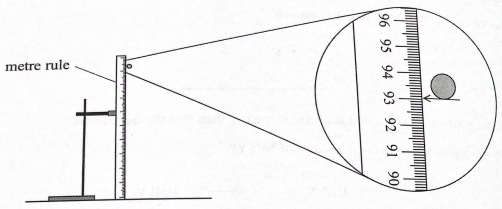
13. 描述 YM in条件

① before PL ② obey Hooke's law ③ $F \propto \Delta x$

2018 卷1

3. 实验题 —— percentage uncertainty

A student carried out an experiment to determine the acceleration of free fall. The initial height of a ball bearing was measured using a metre rule.



What is the best estimate of the percentage uncertainty in the measurement of height?

精度 / 误差

0.1 / 93

6. 力矩

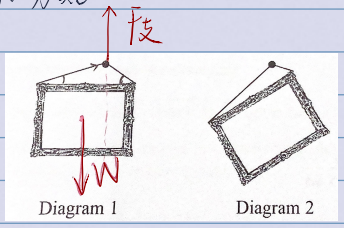


Diagram 1 Diagram 2

导致旋转 in 根本是重力

拉力 对此无意义

weight should act in the same line through nail

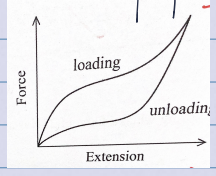
9. thrust 推力

10. 固体材料

- 问词: behaviour
  4 points in 定义
  properties
  gradient - k
  area - EPE
  特殊之
  k is greater

ep. PL: $F \propto \Delta x$

- 能量 (property)



$F_{load} > F_{unload}$

$S_{load} < S_{unload}$

$W_{release} < W_{restore}$

area gap → heat energy

11. 求 spring in Work done

$W = \frac{1}{2} F s$