The LiteSolution Template

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This is the document for LiteSolution template, which provides a lite design of the solution of test paper.

Some designs of this template currently only support **Simplified Chinese (Mainland)**. If necessary, you can change some Chinese characters to the language you want in the `*.cls` file.

1. Introduction

1.1 The purpose of this template

This template provides a lite and fresh template, and mainly used for typesetting solutions of mid-term or final exam, textbooks and other exercises. This template is developed based on ElegantBook and VividBooK, ported and improved the chapter design module code of The Legrand Orange Book. I'd like to express my gratitude to the template authors above for their previous work.

If you meet bugs when using this template, or you have better suggestions or ideas, or you want to participate in the development of the template or other templates by me, welcome to contact via email xiamyphys@gmail.com.

Also, you can join my LaTeX Template Discussion QQ Group: 760570712 to communicate with me and get the insider preview edition of the template.

1.2 Loading LiteSolution and its modes

You should update all the packages to the latest version or switch to portable version instead by implementing the commands

```
tlmgr update --self --all --reinstall-forcibly-removed
```

To learn more, please refer to How do I update my TEX distribution?

Save the file `litesolution.cls` to your project's root directory, and then create a `.tex` file, just input the command `\documentclass{litesolution}` on the first line.

The template provides 3 modes, answer, mtpro2 and counter. Just add the options of the modes you want separately in the square bracket of the command `\documentclass[options]{litesolution}` in your `.tex` file.

2. Modes of LiteSolution

2.1 The answer mode

This mode has two options, ans and noans, which can show and hide answers respectively. After you choose the noans, the contents in the environment solution, the command ans and the answers in the multiple choice questions will all disappear. So the area that originally contained the answer will be replaced by an area of the same blank size. You can generate exams without answers and solutions by enabling noans.

2.2 The mtpro2 mode

If you've installed the Mathtime Pro 2 Lite font in your computer, then you can use this mode to change the math font.

2.3 The counter

This mode has two options, separate and continuous, which can make the page counter between chapters be remaked or continuous.The page numbers between each test question will be continuous when you use the continuous mode or the page number of each test question will start from 1 when you use the separate.

3. Commands of LiteSolution

3.1 The chapterimage command

```
\chapterimage{cover1.png}
```

This command can assign the title background image for each subsequent chapter.

3.2 The chapterfont command

```
\chapterfont{PingFang HK}        \chapterfont*{PingFang HK}
```

This command can assign the title font for each subsequent chapter, if you do not use this command, the title font will be songti in Chinese and Libertinus in English.

If a star (*) is added after the `\chapterfont`, then TeXLive will call the font file from the current path, note from the system. And the file in the current path only support the `.ttf` format.

3.3 The ans command

This command can underlines the answer and changes the color of the answer to Blue Sapphire.

If mode noans is enabled, the answer will disappear, leaving only a horizontal line the same width as the answer.

3.4 The solute command

```
\solute{3} % create a solution box with the height of 3em.
```

This command can create a fixable solution box when the mode noans is enabled.

3.5 The watermark command

```
\watermark{ctanlion.pdf}
```

This command can add watermark to the document.

3.6 Other customer commands

In order to facilitate input, the following commands are scheduled. You can add others in the `*.cls` file as you like.

Command	Output	Command	Output	Command	Output
`\titlelogo{#1}{#2}`	Add emoji with link in text	`\point{#1}`	Add score	`\i`	i
`\sokka{#1}`	故本题选择 #1 项	`\d`	d	`\e`	e
`\xSim[#1]{#2}`	$\overset{r_2+r_1}{\sim}_{r_1\times 2}$	`\ee{#1}`	$\times 10^{-34}$	`\mat{#1}^\T`	$\mathbf{A}^{\mathsf{T}}$
`\rank{#1}`	$\mathrm{R}(\mathbf{AB})$	`\QED`	Q.E.D.	`$5\unit{kg}$`	5 kg

4. Environments of LiteSolution

4.1 The choice environment

There're two variables in this envrionment. The first one is the answer of the choice problem, the second one is the keywords of this choice problem and it's optional.

```
\begin{choice}{D}[Keywords]
If you want to add choice and keywords.
\begin{tasks}(2) % 2 choices per line
    \task This is choice A  \task This is
    choice B
    \task This is choice C  \task This is
    choice D
\end{tasks}
\end{choice}
```

题目 1 Keywords 【 D 】

If you want to add choice and keywords.

A. This is choice A B. This is choice B

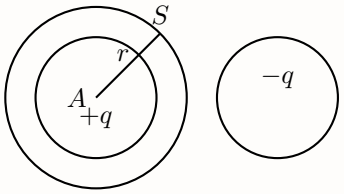
C. This is choice C D. This is choice D

题目 2 **Gaussian theory** 【 D 】

A 和 B 为两个均匀带电球体，A 带电荷 $+q$，B 带电荷 $-q$，作一与 A...

A. 通过 S 面的电场强度...　　B. 通过 S 面的电场强度...

C. 通过 S 面的电场强度...　　D. 通过 S 面的电场强度...




```
\begin{paracol}{2}
\begin{choice}{D}[Gaussian theory]
    $A$和$B$为两个均匀带电球体，$A$带电荷$+q$，$B$带电荷$-q$，作一与$A$...
    \begin{tasks}(2)
        \task 通过$S$面的电场强度...        \task 通过$S$面的电场强度...
        \task 通过$S$面的电场强度...        \task 通过$S$面的电场强度...
    \end{tasks}
\end{choice}
\switchcolumn\centering\vfill\tikz{...}\vfill
\end{paracol}
```

4.2 The problem environment

Sightly different from the cmdchoice environment: the two variables are points and keywords, and the question number counter is shared with the multiple-choice question number counter.

```
\begin{problem}[Keywords][5]
    If you want to add keywords and points.
\end{problem}
\begin{problem}
    If you want to add none.
\end{problem}
\begin{problem}[Keywords]
    If you want to add keywords only.
\end{problem}
\begin{problem}*[][5]
    If you want to add points only.
\end{problem}
```

题目 3（本题 5 分） **Keywords**

If you want to add keywords and points.

题目 4

If you want to add none.

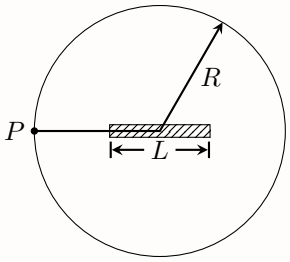
题目 5 **Keywords**

If you want to add keywords only.

题目 6（本题 5 分）

If you want to add points only.

题目 7（本题 6 分） **Gaussian theory & Field strength**



一均匀带电直导线长为 d，电荷线密度为 $+\lambda$. 过导线中点 O 作一半径为 R（$R > \frac{d}{2}$）的球面 S，P 为带电直导线的延长线与球面 S 的交点. 则通过该球面的电场强度通量 $\Phi_e = \underline{\frac{\lambda d}{\varepsilon_0}}$，带电直线的延长线与球面交点 P 处的电场强度的大小为 $\underline{\frac{\lambda d}{4\pi\varepsilon_0(R^2 - d^2/4)}}$，方向 $\underline{\text{沿矢径 } \overrightarrow{OP}}$.

```
\begin{paracol}{2}
    \begin{problem}[Gaussian theory \& Field strength][6]
        一均匀带电直导线长为$d$，电荷线密度为$+\lambda$，过导线中点$O$...
        场强大小\ans{$\frac{\lambda d}{4\pi\varepsilon_0(R^2-d^2/4)}$}...
    \end{problem}
\switchcolumn\centering\vfill\tikz{...}\vfill
\end{paracol}
```

4.3 The note environment

```
\begin{note}
    Please note that...
\end{note}
```

注意

Please note that...

4.4 The proof environment

```
\begin{proof}
    Due to \emph{Langrange's Thorem}...
\end{proof}
```

证明. Due to Langrange's Thorem... Q.E.D.

If a star (*) is added after the `\begin{solution}`, then the content will follow the

```
\begin{proof}*
    Due to \emph{Langrange's Thorem}...
\end{proof}
```

证明. Due to Langrange's Thorem...

4.5 The solution environment

```
\begin{solution}
    This is the answer for the problem.
\end{solution}
```

分析与解

This is the answer for the problem.

If a star (*) is added after the \begin{solution}, then the content will follow the

```
\begin{solution}*
    This is the answer for the problem.
\end{solution}
```

分析与解 This is the answer for the problem.

If mode noans is enabled, the solution will disappear, leaving only a blank box with the same height as the solution, and the name of the box will change to 答题区域.

5. Known Issues

TEXLive will return errors when you enable the mode noans and use the solution environment in paracol environment.

6. Version History

This template is used to type the mid-term and final exam solutions of College Physics. Initially, I used the ElegantBook template for layout, however, it's no longer be maintained since January 1st, 2023, so I turn to use the VividBooK instead. But this template is too bloated and some functions & designs need to be redesigned, so I started developing LiteSolution.

Version 0.1a was finished developing on 29 June, 2023 and released on WeChat Public Account: 物理问题作 with the name FreshSolution. This version redesigned the exercise environment and the solution environment in terms of designs and functions, and improvements have been made to the design of the chapterimage part.

Version 0.1b was finished developing on 6 July, 2023 and released on LaTeX Studio (Xiaoshan, Hangzhou) and Xiaohongshu, where won the favor of many people. This version has added the global option to make the page number be remaked or continuous between chapters, and command watermark has been added in this version.

Version 1.0a was finished developing on 15 November, 2023. This version has redesigned the chapterimage part, choice and replaced the exercise environment with the problem environment.

Version 1.2a was finished developing on 13 November, 2023. This version has integrated the chapter design of ElegantBook into the star (*) key value of this template chapter. And some commands friendly for matrices typesetting were added in. The command chapterfont was redesigned that it can call the font in the local path or call system font with(out) a star (*) after it. Also, the environment proof was redesigned, and the mode noans in this version supports hide the solution box and replace it with a fixable solution box. Today (2023/12/13) is The National public memorial day of Nanjing Massacre. Hope for world peace.

Update Announcements

2023/07/06 Update: Version 0.1b

- Support page number remaking between chapters.
- Added watermark command.

2023/11/15 Update: Version 1.0a

- Redesigned the chapterimage part, include the layout and the code.
- Redesigned the choice and solution environment, keywords become optional and supports star (*) key.
- Replaced the exercise environment with the problem environment, supports adding only keywords or points.
- Added the note environment and some customer commands.

2023/12/13 Update: Version 1.2a

- Fixed the bug that the gap around the chapter image.
- Added some commands for matrices.
- Redesigned the chapterfont command.
- Redesigned the proof environment.
- Supports to adjust the height of solution box when output the exam paper without answer.
- Add the 排版规范 in 中文（简体） after the package document.
- Fixed the bug that warnings of the packages xeCJK and fontspec.

Future Plans

- Plan to add the dark mode to this template to make the text color light while make the page color dark to protect eyesight.
- Plan to change the `*.cls` file to a block code design to make it easier for subsequent developers to maintain or modify.
- .....

A Sample for LiteSolution Template

考试时间：2023 年 12 月 3 日　　**任课教师**：大学物理教学团队

课程编号：A0715012　　**解析制作**：物理問題作

CTAN　　GitHub

1. 选择题（每题 3 分，共 36 分）

题目 1　　弹簧振子　【 D 】

一劲度系数为 k 的轻弹簧，下端挂一质量为 m 的物体，系统的振动周期为 T_1. 若将此弹簧截去一半的长度，下端挂一质量为 $m/2$ 的物体，则系统振动周期 T_2 等于

A. $2T_1$　　B. T_1　　C. $\dfrac{T_1}{\sqrt{2}}$　　D. $\dfrac{T_1}{2}$

分析与解 弹簧的劲度系数与长度成反比，所以剪断一半后劲度系数变为 $2k$；根据弹簧振子的周期表达式 $T=2\pi\sqrt{\dfrac{m}{k}}$ 可知此时的周期 $T_2=2\pi\sqrt{\dfrac{m/2}{2k}}=\dfrac{T_1}{2}$. 故本题选择 **D** 项.

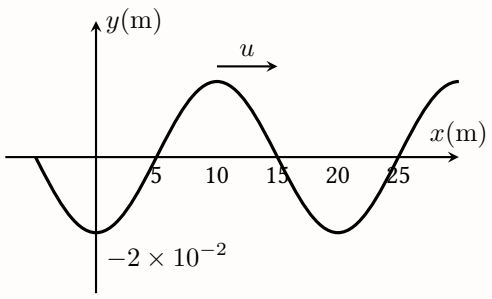
题目 2　　单摆　【 B 】

把单摆摆球从平衡位置向位移正方向拉开，使摆线与竖直方向成一微小角度 θ，然后由静止放手任其振动，从放手时开始计时. 若用余弦函数表示其运动方程，则该单摆振动的初相为

A. θ　　B. 0　　C. $\dfrac{\pi}{2}$　　D. $-\pi$

题目 3　　平面简谐波的波函数　【 A 】

一平面简谐波，波速 $u=5\mathrm{m/s}$，$t=3\mathrm{s}$ 时波形曲线如图，则 $x=0$ 处质点的振动方程可能为



A. $y=2\times10^{-2}\cos\left(\dfrac{1}{2}\pi t-\dfrac{1}{2}\pi\right)$　　B. $y=2\times10^{-2}\cos\left(\dfrac{1}{2}\pi t+\dfrac{1}{2}\pi\right)$

C. $y=2\times10^{-2}\cos(\pi t+\pi)$　　D. $y=2\times10^{-2}\cos\left(\pi t-\dfrac{3}{2}\pi\right)$

分析与解 由图可知 $A=0.02\mathrm{m}$, $\omega=\dfrac{2\pi u}{\lambda}=\dfrac{1}{2}\pi$. 由于原点处 $v>0$，所以初相 $\varphi=-\dfrac{\pi}{2}$. 故本题选择 **A** 项.

题目 4　　增透膜　　【 A 】

一艘油船行经我国台湾岛东部海域时发生石油泄漏，在海面上形成大片油膜，太阳光在头顶正射时，救授人员乘直升飞机从上往下看，发现油膜对 552nm 波长的可见光反射形成干涉相长而最亮，则可以推测该区域油膜厚度可能为多少?（设石油折射率 $n=1.2$，海水折射率 $n=1.3$）

A. 460nm　　B. 552nm　　C. 345nm　　D. 425nm

分析与解

- 由于 $n_{空}>n_{海}>n_{油}$，所以石油两个表面反射光光程差为 $\delta=2ne$.
- 使反射光干涉相长，即 $2ne=k\lambda$. A 选项刚好满足 $k=2$ 时，$e_{\min}=2\cdot\dfrac{\lambda}{2n}=460\text{nm}$.

题目 5　　光程和光程差　　【 C 】

在相同的时间内，一束波长为 λ 的单色光在空气中和在玻璃中

A. 传播的路程相等，走过的光程相等　　B. 传播的路程相等，走过的光程不相等

C. 传播的路程不相等，走过的光程相等　　D. 传播的路程不相等，走过的光程不相等

分析与解 光程的定义：在相同时间内光线在真空中传播的距离. 题目中光传播时间相同，故光程相等；又因为光在两种介质中的传播速度不同，所以在相同的时间内传播的路程不相等. 故本题选择 C 项.

题目 6　　多普勒效应　　【 C 】

一观察者站在铁路旁，一火车以 30m/s 的速度向他驶来并发出频率为 440Hz 的汽笛声. 已知空气中声速为 330m/s，问观察者听到的火车频率为

A. 403Hz　　B. 480Hz　　C. 484Hz　　D. 528Hz

分析与解

已知多普勒效应观察者（Observer）和发射源（Source）的的频率关系为

$$\nu=\frac{u\pm v_o}{u\mp v_s}\nu_0$$

v_o 为观察者速度，接近为 +，远离为 −；v_s 为发射源速度，接近为 −，远离为 +. 观察者静止，其所听频率为

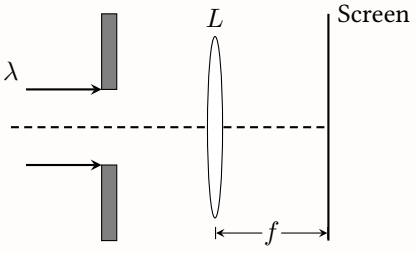
$$\nu=\frac{330}{330-30}\times 440\text{Hz}=484\text{Hz}$$

故本题选择 C 项.

题目 7　　弗琅禾费衍射　　【 C 】

在如图所示的单缝弗琅禾费衍射实验中，若将单缝沿透镜光轴方向向透镜平移，则屏幕上的衍射条纹

A. 间距变大　B. 间距变小　C. 不变化　D. 间距不变，明暗纹交替



分析与解 条纹间距只与波长、焦距、缝宽有关，入射光方向不变，所以条纹间距、位置不变. 故本题选择 C 项.

题目 8　　牛顿环　　【 A 】

牛顿环干涉装置上平凸透镜在垂直于平板玻璃的方向上，逐渐向下平移（靠近玻璃板）时，反射光形成的干涉条纹的变化情况是

A. 环纹向边缘扩散，环数不变　　B. 环纹向边缘扩散，环数增加

C. 环纹向中心靠拢，环数不变　　D. 环纹向中心靠拢，环数增加

分析与解 对于某条环，其光程差是确定的，所以环数不变；向边缘扩散光程差增大，可抵消透镜下移时导致的光程差减小. 故本题选择 A 项.

题目 9　　最大分辨力　　【 B 】

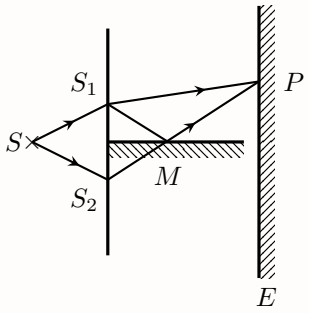
假设用 FAST 装置探测波长为 20cm 的宇宙射电信号，FAST 望远镜的镜面直径为 500m，则装置的最小分辨角为

A. 9.76×10^{-4}　　B. 4.88×10^{-4}　　C. 2.44×10^{-4}　　D. 4.00×10^{-4}

分析与解 $\theta=\dfrac{1.22\lambda}{D}=4.88\times10^{-4}\text{rad}$. 故本题选择 B 项.

题目 10　　双缝干涉　　【 B 】

在双缝干涉实验中，屏幕 E 上的 P 点是明纹. 若将缝 S_2 盖住，并在 S_1S_2 连线的垂直平分面处放一高折射率反射面 M，如图所示. 则此时 P 点



A. P 点仍为明条纹　　B. P 点为暗条纹

C. 不能确定 P 点是明纹还是暗纹　　D. 无干涉条纹

分析与解 S_1MP、S_2MP 长度相等，但平面镜使在反射中一条光路发生半波损失，两条光路的相位差变化 π，所以 P 点由原来的明纹变为暗纹. 故本题选择 B 项.

题目 11　　迈克尔逊干涉仪　　【 A 】

如果使迈克尔逊干涉仪的动镜移动 0.233mm，观察到 792 个条纹的移动，则所用照明单色光源的波长是多少?

A. 588nm　　B. 294nm　　C. 442nm　　D. 552nm

分析与解 移动带来的光程差满足 $\delta=2d=N\lambda$，由此得 $\lambda=\dfrac{2d}{N}=588.38\text{mm}$. 故本题选择 A 项.

题目 12　　光栅　　【 B 】

某元素的特征光谱中含有波长分别为 $\lambda_1=450\text{nm}$, $\lambda_2=750\text{nm}$ 的谱线，在光栅光谱中这两种波长的谱线有重合现象，重叠处 λ_2 的谱线级数将是

A. $2,\ 4,\ 6,\ 8,\cdots$　　B. $3,\ 6,\ 9,\ 12,\cdots$　　C. $4,\ 8,\ 12,\ 16,\cdots$　　D. $5,\ 10,\ 15,\ 20,\cdots$

分析与解 由光栅方程 $d\sin\theta=k_1\lambda_1=k_2\lambda_2$ 得 $k_2=\dfrac{k_1\lambda_1}{\lambda_2}$，取整值得 $k_2=3,6,9,12,\cdots$.

2. 填空题（共 18 分）

题目 13（本题 3 分）　　弹簧振子

当弹簧振子以频率 f 做简谐振动时，它的动能的变化频率为 $2f$.

分析与解 动能和势能变化趋势相反，所以二者变化频率相同. 势能 $E_p \propto x^2$，由于 x 是周期为 T 的余弦函数，所以 x^2 的周期为 $\frac{T}{2}$，即势能的变化频率等于动能的变化频率等于 $2f$.

题目 14（本题 3 分）　　驻波

在均匀介质中，一列余弦波沿 Ox 轴传播，波动方程为 $y_1 = A\cos\left(2\pi t + \frac{2\pi x}{3}\right)$ (SI)，在 $x = 1\text{m}$ 处反射，反射点为固定端，则反射波和入射波产生的驻波表达式为 $2A\cos\left(2\pi t + \frac{7\pi}{6}\right)\cos\left(\frac{2\pi x}{3} - \frac{7\pi}{6}\right)$.

分析与解

- 考虑反射带来的半波损失，$x = 1\text{m}$ 处反射波的振动方程为 $y_{10} = A\cos\left(2\pi t + \frac{2\pi}{3} + \pi\right)$.
- 反射后传播方向改变，考虑以 $x = 1$ 处为参考点需坐标变换 $x' = x - 1$，所以反射波的表达式为
$$y_2 = A\cos\left(2\pi t + \frac{2\pi}{3} - \frac{2\pi(x-1)}{3} + \pi\right) = A\cos\left(2\pi t - \frac{2\pi x}{3} + \frac{7\pi}{3}\right)$$
- 驻波表达式 $y = y_1 + y_2 = 2A\cos\left(2\pi t + \frac{7\pi}{6}\right)\cos\left(\frac{2\pi x}{3} - \frac{7\pi}{6}\right)$.

题目 15（本题 6 分）　　双缝干涉

如图所示，在双缝干涉实验中，若把一厚度为 e、折射率为 n 的薄云母片覆盖在 S_1 缝上，中央明条纹将向 上 移动；覆盖云母片后，两束相干光至原中央明纹 O 处的光程差为 $(n-1)e$.

分析与解 覆盖云母片后，通过 S_1 的光路光程差变大，为抵消这一变化中央明纹需上移使通过 S_2 的光路变长；原光程差为零，现光程差即云母片带来的光程差 $\delta = ne - e = (n-1)e$.

题目 16（本题 3 分）　　牛顿环

若把牛顿环装置（都是用折射率为 1.52 的玻璃制成的）由空气搬入折射率为 1.33 的水中，则干涉条纹 变密（变疏/变密）.

分析与解 放入水中后每条条纹的光程差变大，为抵消这一变化条纹需向中心收缩，所以干涉条纹变密.

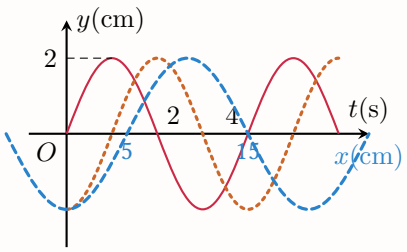
题目 17（本题 3 分）　　弗琅禾费衍射

在单缝夫琅禾费衍射实验中，波长为 λ 的单色光垂直入射在宽度为 $a = 6\lambda$ 的单缝上，对应于衍射角为 $30°$ 的方向，单缝处波阵面可分成的半波带数目为 6.

分析与解 由衍射公式 $a\sin\theta = k\lambda$ 得 $k = 3$，可分成的半波带数目为 $2k = 6$.

3. 计算题（共 46 分）

题目 18（本题 10 分）　　平面简谐波的波函数



一列平面简谐波在媒质中以波速 $u = 5\text{m/s}$ 沿 x 轴正向传播，原点 O 处质元的振动曲线如图所示.

1. 求解 $x = 25\text{m}$ 处质元的振动方程并画出该点振动曲线.
2. 求解波动方程，并画出 $t = 3\text{s}$ 时的波形曲线.

分析与解

1. 由图知振幅 $A = 0.02\text{m}$，角频率 $\omega = \dfrac{2\pi}{T} = 0.5\pi\text{s}$. $t = 0$ 时，$y = 0$, $v > 0$，初相 $\varphi = -\dfrac{\pi}{2}$. 波动方程为 ⋯ (2pt)

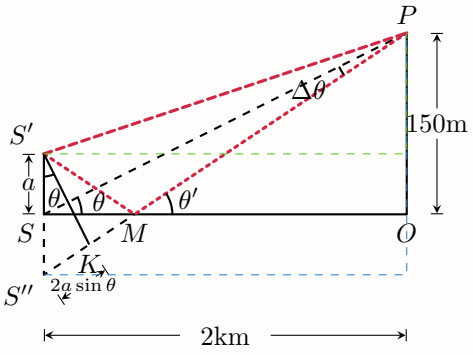
$$y = 0.02\cos\left[\frac{\pi}{2}\left(t - \frac{x}{5}\right) - \frac{\pi}{2}\right] \qquad \text{(2pt)}$$

$x = 25\text{m}$ 处质元的振动方程为 $y(x_0, t) = 0.02\cos\left(\dfrac{\pi}{2}t - \pi\right)$. ⋯⋯ (2pt)

2. 波动方程见上问. $t = 3\text{s}$ 时的波形方程为

$$y(x, t_0) = 0.02\cos\left(-\frac{\pi}{10}x + \pi\right) \qquad \text{(2pt)}$$

题目 19（本题 8 分）　　光程和光程差



[a] 一艘船（如图中 S）在 25m 高的桅杆（SS'）上装有一天线（如图中 S''），不断发射某种波长的无线电波，已知波长在 $2-4\text{m}$ 范围内，在高出海平面 150m 的悬崖顶（OP）上有一接收站 P 能收到这无线电波，但当那艘船驶至离悬崖底部 $OS = 2\text{km}$ 时，接收站就收不到无线电波. 设海平面完全反射这无线电波，求所用无线电波的波长.

[a] 选自 37th CPhO 预赛试题第 10 题，原题未并提供参考图片.

分析与解

考虑半波损失，经海平面反射的光波与直达 P 点的光波之间的光程差为

$$\delta = 2a\sin\theta + \frac{\lambda}{2} \qquad \text{(3pt)}$$

由几何关系 $\sin\theta = \sin\arctan\left(\dfrac{150}{2000}\right) = 0.075$. 利用干涉相消条件得无线电波长为 ⋯⋯ (2pt)

$$\delta = \frac{2k+1}{2}\lambda,\ \lambda = \frac{2a\sin\theta}{k} \xlongequal[2<\lambda<4]{k=1} 3.74\text{m} \qquad \text{(3pt)}$$

本题中 $\Delta\theta$ 不可忽略，不得认为 $\theta = \angle PMO$! 否则会得到 $k = 2.18$.

另一种更精确的解法是直接计算两条光路的长度之差[a]

$$\delta = \overline{S''P} - \overline{S'P} + \frac{\lambda}{2} = \sqrt{(\overline{SO})^2 + (\overline{OP} + \overline{SS''})^2} - \sqrt{(\overline{SO})^2 + (\overline{OP} - \overline{SS''})^2} + \frac{\lambda}{2}$$

$$= \sqrt{2000^2 + (150+25)^2} - \sqrt{2000^2 + (150-25)^2} + \frac{\lambda}{2} = \frac{2k+1}{2}\lambda$$

解得 $\lambda \xlongequal{k=1} 3.74\text{m}$.

[a] 值得一提的是，因上一种解法近似认为 $S'K \perp S''K$，相对于这种解法有 $7.73 \times 10^{-3}\%$ 的误差（小数点第四位及以后不同）.

题目 20（本题 10 分）　薄膜干涉

波长为 $\lambda = 500\text{nm}$ 的单色光垂直入射到**置于空气中**的上下表面平行的薄膜上，已知膜的折射率 $n = 1.25$，求反射光、透射光最强时膜的最小厚度.

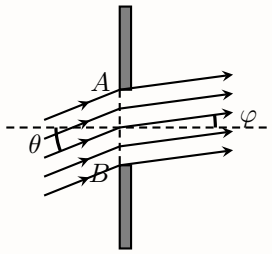
分析与解 两个表面反射光光程差为 $\delta = 2ne + \dfrac{\lambda}{2}$. 分别由反射光干涉相长 $\delta = k\lambda$ 和相消 $\delta = \dfrac{2k+1}{2}\lambda$ 得 ·· (4pt)

$$e_{\min_1} = \frac{\lambda}{4n} = 100\text{nm},\ e_{\min_2} = \frac{\lambda}{2n} = 200\text{nm} \qquad \text{(4pt)}$$

- 反射光干涉相长时，反射光最强，膜的最小厚度为 $e_{\min_1} = 100\text{nm}$. ····· (1pt)
- 反射光干涉相消时，透射光最强，膜的最小厚度为 $e_{\min_2} = 200\text{nm}$. ····· (1pt)

题目 21（本题 12 分）　光栅

如右图所示，AB 之间的虚线为一透射式光栅，该光栅在 1mm 内刻画有 500 条狭缝，单条狭缝的缝宽为 $a = 0.5\mu\text{m}$，一波长为 $\lambda = 500\text{nm}$ 的单色平行光斜入射在该光栅上，入射角 $\theta = 30°$（从光栅光轴下方入射），在光栅后放置凸透镜和观察屏（屏位于透镜的焦平面处），问屏上能看到哪几级谱线?



分析与解 光栅常数 $d = \dfrac{1\times10^{-3}}{500} = 2\mu\text{m}$. 由于光栅方程 ····· (2pt)

$$d(\sin\varphi - \sin\theta) = k\lambda \qquad \text{(2pt)}$$

- 令 $\varphi = \pm90°$ 得 $k_{\min} = -6,\ k_{\max} = 2$. 由缺级条件得 $k' = \dfrac{d}{a} = \pm4$，第 -4 级缺级. ····· (4pt)
- 由于 φ 无法取到 $\pm90°$，所以屏上可见主极大级次为 $k = 0,\ \pm1,\ -2,\ -3,\ -5$. ····· (4pt)

题目 22（本题 6 分）　驻波

由振动频率为 400Hz 的音叉在两端固定拉紧的弦线上建立驻波. 这个驻波共有三个波腹，其振幅为 0.30cm，波在弦上的速度为 320m/s.

1. 求此弦线的长度.
2. 若以弦的中点为坐标原点，试写出弦线上驻波的表达式.

分析与解

1. 由题意得弦长为 1.5 个波长，即 $l = 1.5\lambda = 1.5\dfrac{u}{f} = 1.2\text{m}$. ····· (2pt)
2. 驻波的角频率 $\omega = 2\pi f = 800\pi$，波矢 $k = \dfrac{2\pi}{\lambda} = \dfrac{5}{2}\pi$. 设驻波的表达式为

$$y = 3\times10^{-3}\cos(800\pi t + \phi)\cos\left(\frac{5}{2}\pi x + \varphi\right) \qquad \text{(2pt)}$$

中点 $x = 0$ 处是波腹，所以 $\cos\varphi = 1$，$\varphi = 0$ or π. 所以驻波的表达式为

$$y = \pm3\times10^{-3}\cos(800\pi t + \phi)\cos\left(\frac{5}{2}\pi x\right) \qquad \text{(2pt)}$$

符号 $\pm$ 对应 φ 的两个解，ϕ 由初始条件决定.

LiteSolution 试卷解析模板排版规范

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1. 模板介绍

本模板用于高校期中 & 期末试卷排版，支持一键输出无答案试卷.

2. 数学公式

2.1 正体问题

1. 微分算符要使用正体：`\d`.
2. 自然对数要使用正体：`\e`.
3. 三角函数、exp 正体：`\function`
4. 撇`'`和`^\prime`的作用相同：TeX Stackexchange.

2.2 行内 & 行间公式

1. 行内公式：要`$ ... $`不要`\( ... \)`
2. 行间公式：要`\[ ... \]`不要`$$ ... $$`

至于为何，“不要”的命令在 LaTeX 中属于「脆弱」命令，这里不做详解.

LaTeX 中的「要」和「不要」- 知乎

2.3 选填题

1. 使用 tasks 环境判断高度

```
\begin{tasks}(一行选项个数，自己掂量)
 \task 选项1 \task 选项2
 \task 选项3 \task 选项4
\end{tasks}
```

不要使用`tabular`制作选择题选项，选项不是画表格!

2. 答案不要擅自使用`\underline{}`命令，而是使用`\ans{}`命令，否则制作空白无答案版时答案将无法隐藏.

2.4 等高括号

1. 凡是你觉得很高的都需做等高括号处理：`\ab( )`, `\ab[ ]`, `\ab\{ \}`
2. 但也不要所有括号都做等高处理，比如`f\ab(x)`和`f(x)`的效果是一样的，多一个`\ab`判断高度只会徒增编译时间.

3. 偷懒技巧

以`\frac{}{}`为例

1. `\frac12 == \frac{1}{2}, \frac\pi2 == \frac{\pi}{2}, \frac yx == \frac{y}{x}`
2. `frac{}{}`后跟两个键值，如果未使用`{}`界定作用域，则默认 scan 到第 1 个 char 或宏（如`\alpha`）时将其放入第一个键值，scan 到第 2 个 char 或宏（如`\alpha`）时将其放入第 2 个键值.
3. 不会用的话别乱用，老实儿使用`{}`界定作用域，不要出现诸如`\frac x'2`: $\frac{x}{'}2$（事实你要写的是 $\frac{x'}{2}$）.

4. 排版美观

1. 尽量不要（甚至杜绝）题目在上一页，答案在下一页的情况（**六级完形文章和题目不在一页的痛你应该经历过**）.
2. 杜绝出现题目/解答盒子断开跨页的情况，这很不美观. 如果一个题目解析实在过长，请尝试缩句，或者使用分栏`multicols`环境以节省空间.
3. 如果因第 $n+1$ 页开头的题目盒子高度小于第 n 页末尾剩余了空间而导致了空间浪费，请试着将后文中高度与第 n 页最后一道题目 + 剩余空间相当的题目位置与其交换.
4. 最完美的排版：除非遇到下一个`section`，每一页从头到尾都恰好填满了题目与解析.